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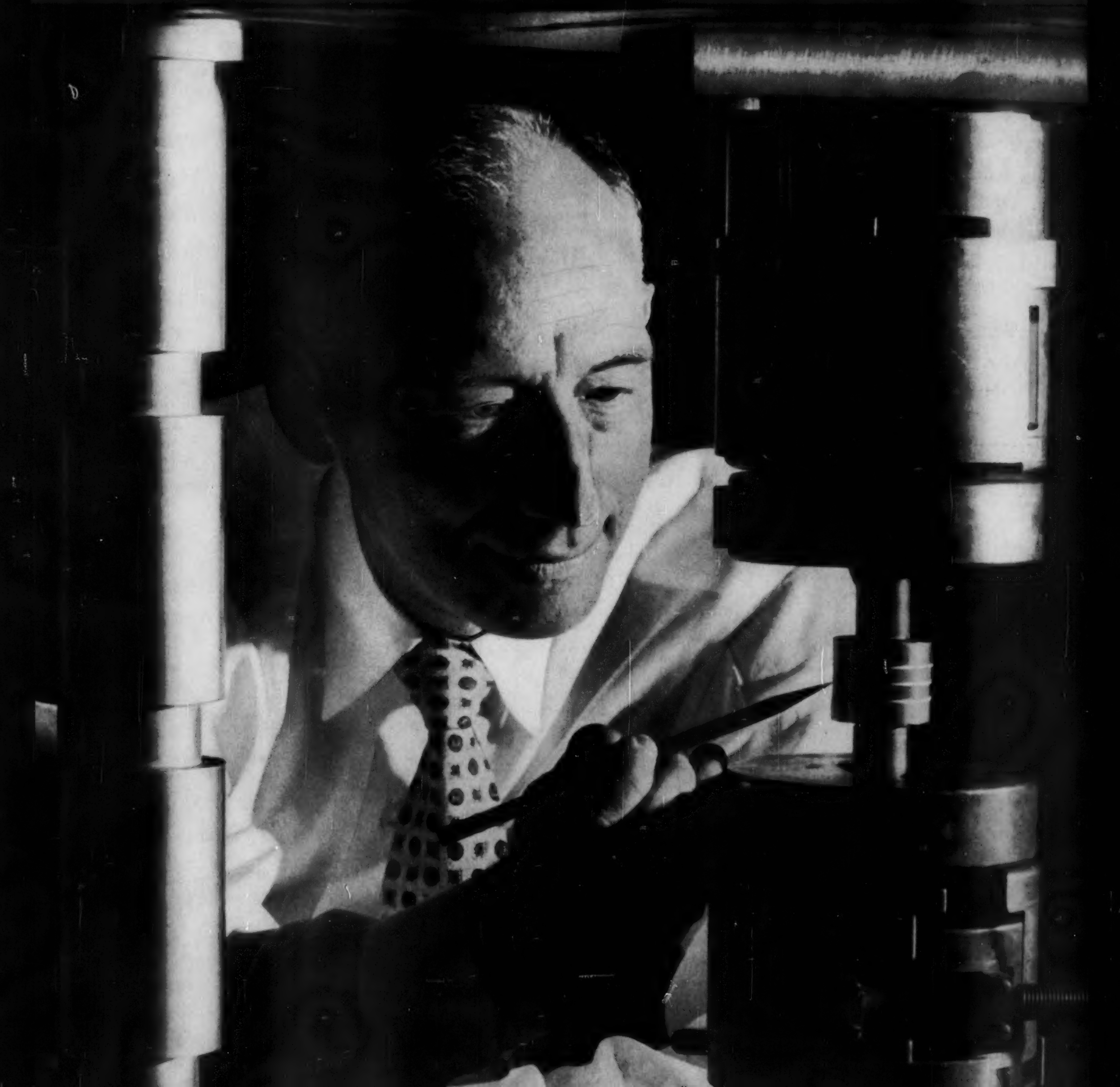

Bell Laboratories RECORD

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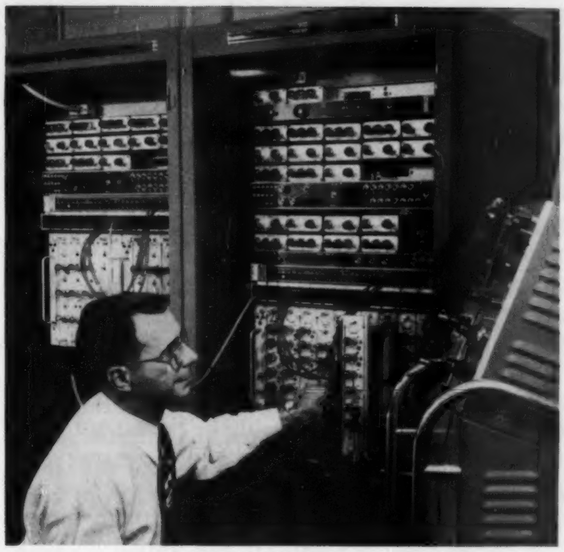


SAGE Data Transmission Service

A. E. RUPPEL *Special Systems Planning*

The vast communications network of the telephone industry and its trained personnel, including the technical experience of the Laboratories, have been called upon to provide vital communications links to integrate the continental defense system known as SAGE. This system has been designed to collect and collate data related to thousands of aircraft flights each day, and to help guide interceptor action in the event of an enemy attack. The Laboratories has also developed the high-speed digital data system for SAGE. This data system can be applied to the types of transmission facilities commonly found in the telephone plant.

The major defenses of our country against surprise air attacks include a complex array of radar networks and strategically located interceptor-fighter planes and missiles. The radar networks include the DEW (Distant Early Warning*) Line which extends across the top of Alaska and Canada, the Mid-Canada Line which extends across Canada from British Columbia to Newfoundland and the Pine Tree Line which protects our northern border. Our coast lines are protected by a radar network operating many miles at sea. The radar stations in this network include the Navy picket ships, the AEW&C (Airborne Early Warning and Control) aircraft, and the Texas Towers, which are man-made islands of steel anchored to the ocean shoals. Within our borders, detection is accomplished by a network of surveillance and height-finder radars as well as the Ground Observer Corps.

These radar stations determine the bearing, range, altitude and speed of each aircraft detected. The information is used to identify the aircraft, or if it cannot be identified, to assist in the intercepting operations. Since one radar "fix" is not sufficient to provide the necessary data, the information is obtained continuously and is reported at periodic intervals. A plot of this information is called an "air track." To identify detected aircraft, each of these air tracks must be related to flight plans from Civil Aeronautics Authority and military flight service centers. If, as a result of this analysis, a plane remains unidentified and an interception is desired, additional information must be obtained from the Air Weather Service and various interceptor bases.

Today this vast defense system is manually operated. Detection information must be read from radar scopes by trained observers. It must then be forwarded to a processing center which acts as a clearing house for a relatively large area covered by many radar stations. Here the information must be plotted and correlated with the proper flight plans.

* RECORD, *May*, 1957, *page* 194.

If an aircraft is completely identified, this information must be forwarded to the adjacent processing center in the plane's course. If identification is not made, the information must be relayed to the Continental Air Defense Command (CONAD).

CONAD is responsible for our entire continental air defense. Besides having the authority to order an interception by Air Force interceptors, Navy planes, Army anti-aircraft guns, or missiles, CONAD is also responsible for alerting Federal Civil Defense authorities, the Federal Communications Commission and the Civil Aeronautics Administration.

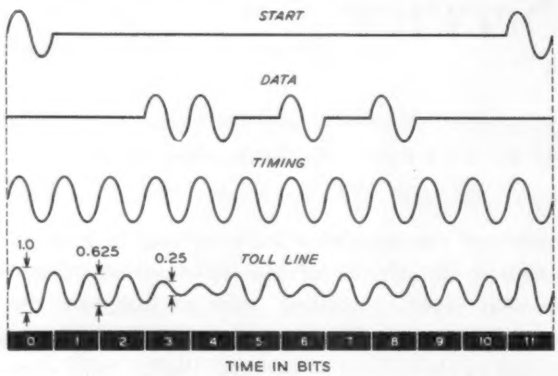


Fig. 1 — Typical wave-forms used in the A1 system.

Each of these operations must be carried out by individuals who transmit the information either by teletypewriter or voice telephone. When one considers the approximately 30,000 scheduled flights a day, the many more unscheduled flights, and the ever-increasing speed of aircraft, it becomes apparent that, even with highly trained and efficient personnel, this manual system is doomed to early obsolescence. A solution to this problem is SAGE.

SAGE is not an entirely new defense system, but is automation applied to an existing system. The word SAGE is derived from the words "Semi-Automatic Ground Environment." "Semi-Automatic" describes the information transmission and processing techniques. "Ground Environment" is an Air Force term that refers to any electronic system at ground locations which is used to provide some sort of operational service.

When they are used with the SAGE system, the radar sets will be equipped with a device to convert the radar signals into a form suitable for transmission to data-processing centers over telephone message circuits. At the data-processing centers, the radar signals can be fed directly to an electronic computer, or they can be reconverted to a radar signal and displayed on an oscilloscope screen. The computer can continuously relate the information from the many radar stations in its area and from the adjacent data-processing centers to the CAA and military flight plans. The output of the computer is used to identify aircraft as well as to solve the complicated problems of navigation and vectoring for interception by aircraft or missiles. Besides these functions, the computer keeps an active inventory of the status of all weapons. From this description, it can be seen that the giant computers at the data-processing centers are the heart of the SAGE continental defense system.

The network that is required to transmit the information to and from the many computers in the SAGE system will probably be the largest data-transmission network in the world for many years to come. Briefly, the basic requirements of this network are that it be capable of transmitting information at the rate of 1,600 bits per second on some of the circuits and 1,300 bits per second on others. A bit is defined as a mark (a pulse) or a space (no signal at all) occupying one time element of the message 1/1,300 or 1/1,600 of a second.

As an objective, a tentative error rate from all causes including noise and equipment malfunctions has been specified as a maximum of one bit in error per 100,000 bits, or approximately one bit in error per minute per circuit. An error is either a mark converted to a space, or a space converted to a mark. It has been further specified that out-of-service time resulting from any one cause such as a storm, sabotage, or equipment failure shall not be more than 30 seconds for the more critical circuits. Normal restoration time will suffice on all other circuits. In general, the circuits will not be over 300 miles long.

The Air Force has requested that the telephone industry provide the vast data-service network required for SAGE on a leased basis. Although service features differ for the many applications, each circuit is required to transmit the same form of signal. All of the SAGE data generating and using equipment, which is to be government owned and operated, is designed to use a signal having three components: a start pulse to signify the beginning of a message, the data pulses (marks and spaces), and a timing signal which is a continuous sine wave in synchronism with the data bit-rate. Each of these signals is transmitted over a separate input circuit to the data-using equipment or over a separate output circuit from data-generating equipment.

Since the data equipment will be remote from

the terminals of the data-service network, in many cases it will be necessary to use local loop circuits varying from a few hundred feet to several miles long to transmit the start, data and timing signals. In order that normal local exchange-area plant facilities can be used to transmit these signals, the start and data pulses are of a special form called a "dipulse." A single dipulse is one complete sinusoid starting at the zero amplitude point of its cycle. The period of the dipulse is equal to the duration of a single mark or space. Thus, for a 1,300 bits-per-second circuit the dipulse would be one full cycle of a 1,300 cycles-per-second sine wave.

At the input terminals of a data-service toll circuit, the start and data signal components are combined and used to modulate a local carrier. This results in efficient and reliable transmission over a single toll circuit, rather than three separate circuits. At the output terminals of the toll circuit, the line signal is converted back to the start and data components, and the timing signal is regenerated. The three signals are then transmitted over three separate local loop circuits to the data-using equipment. From previous studies and laboratory tests, it has been determined that the most satisfactory modulation system for the transmission of the 1,300 and 1,600 bit rate over the majority of telephone message grade facilities is a vestigial-sideband modulation system. A system of this type has been developed for the SAGE data-transmission service.

The various line signals used in the SAGE data-transmission service are shown in Figure 1. The trace at the top of the figure represents the start dipulses which mark the beginning of each message. These start dipulses are transmitted continuously and are spaced exactly one message length apart, whether or not any data are being transmitted. The message length is a fixed number of bits for any particular application. The second trace is that of the data marks and spaces. As shown, bits 3, 4, 6 and 8 are marks. Timing is shown as the third trace. This signal, like the start pulse, is also transmitted continuously whether or not data are being transmitted.

Before describing the bottom trace in the figure, which represents the vestigial-sideband line signal, several additional facts regarding the signals should be established. The start signal is the most important of the three signal components, since it is used both to indicate the start of a message and to synchronize the regenerated timing signal in the receiving terminal. For this reason, it is transmitted at the highest amplitude-modulation level, and a message format has been chosen to avoid the use of data bits adjacent to either side of the start pulse. This latter condition of always sending spaces immediately before and after the start pulse minimizes distortion of the pulse from dissymmetry in the levels of adjacent pulses.

To reduce further the distortion of the start pulse during transmission, it is desirable to keep transitions in levels in its immediate vicinity at a minimum. Therefore, in the system that was developed, it was decided to have the start pulse transmitted at the highest modulation level, data spaces at the next highest, and marks at the lowest. The line signal shown on the bottom trace is, therefore, a 2-kc carrier with three levels of modulation: a relative amplitude of 1.0 for start pulses, 0.625 for data space signals, and 0.25 for data mark signals. This provides equal amplitude differences among the three different signal components.

The over-all system developed for the SAGE data-transmission service is called the A1 digital data signaling system. It is composed of four basic operating units. One is the Digital Data Transmitter (DDT) which accepts the three component signals – start, data and timing – from the data-generating equipment, and converts them to the 2-kc vestigial-sideband signal. Another of the basic units is the Digital Data Receiver (DDR) which accepts the line signal and converts it back into the three com-

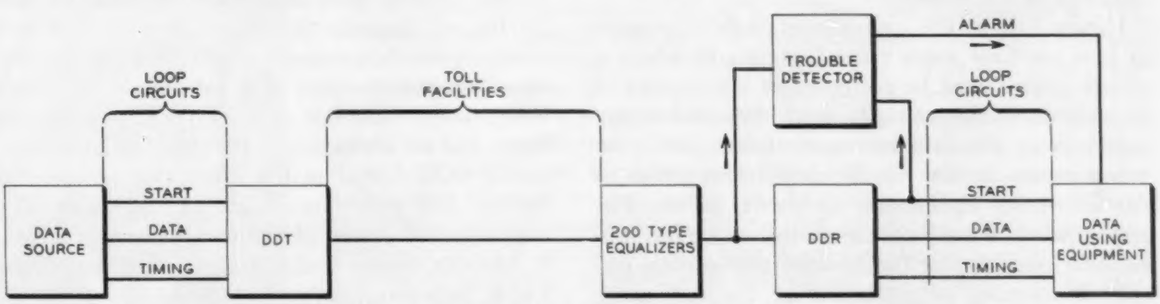


Fig. 2 — Block diagram of A1 digital data signaling system (single-circuit arrangement).

ponent signals for transmission over local facilities to the data-using equipment.

A Trouble Detector (TD), the third basic unit, was developed to meet the no more than 30-second outage time requirement on the more critical circuits. It monitors the line in a frequency range below that of the vestigial-sideband signal. If the noise in the circuit becomes excessive, or if the circuit fails because of excessive loss, the trouble detector generates a signal which operates a Transfer and Control Circuit (TCC). This transfer and control circuit, the fourth basic unit, automatically switches the signal to an alternate route unless the trouble detector indicates that it is also in trouble.

comparison during tests, or to switch routes for routine maintenance procedures.

Although the A1 system has been designed to operate over most message-grade toll facilities, the requirements for data transmission are much more severe than those for message transmission. The circuits in general, therefore, require specialized treatment. The amplitude versus frequency response for the over-all circuit between DDT's and DDR's must not have more than plus or minus 2-db variation from the 1,000 cycle net loss between 1,000 and 2,600 cycles nor more than plus or minus 3-db variation from the 1,000 cycle net loss between 500 and 1,000 cycles. Envelope delay distortion must be no more than 500 microseconds between any two frequencies in the 1,000 to 2,500 cycle band. Any departure from the envelope delay limits can be corrected by using delay equalizers.

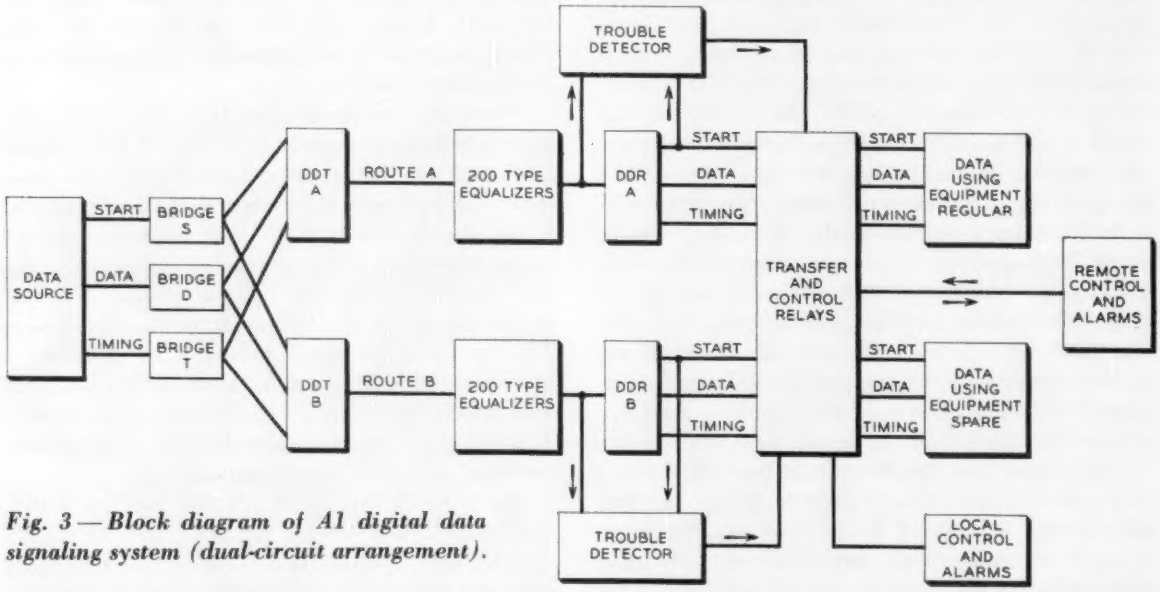


Fig. 3 — Block diagram of A1 digital data signaling system (dual-circuit arrangement).

The A1 system is illustrated in Figure 2 as it is used for one of the less critical circuits in which it is sufficient to correct a circuit failure in the normal restoral time for telephone service. In this case, the trouble detector generates an alarm signal whenever a path becomes excessively noisy or an open circuit develops in the system.

Figure 3 shows the arrangement of the A1 system as it is used for more critical circuits in which a circuit failure must be corrected in a maximum of 30 seconds. In this case, the start, data and timing signals from the data source are transmitted over two separate circuits which use different routes to the data-using equipment. As shown on the diagram, there is a local manual control which has preemptive control over the transfer and control circuit. It permits an attendant at the data-using equipment to choose either of the two routes for

Since the vestigial-sideband modulation system uses amplitude modulation, gain adjusting devices in the circuits inter-connecting the DDT's and DDR's will degrade the transmission if their time constants are fast enough to alter the level difference between the start and data mark and space components of the line signal. Long time variations in net loss are compensated for by a relatively slow-acting AGC circuit in the DDR that is operated by the start pulse component of the signal. The relatively fast action of the compandors in the O, N, and ON carrier facilities, however, degrades the SAGE data-transmission by several db. To overcome this condition, a special service channel unit

that operates as a fixed-gain device has been developed for these systems.

In systems such as the L3 carrier, channels are switched to stand-by facilities which provide alternate paths during equipment troubles. These systems must be carefully maintained to minimize the transients developed during the switching interval or any differences in net loss between the switched facilities. As indicated on the lower trace in Figure 1, there is only a 4-db difference between the peak of the start signal and the peak of space signals, and an 8-db difference between the peak of a space signal and the peak of a mark signal. The level above which a signal is recognized as a start and below which a signal is recognized as a space is called the "slice level." It is adjusted to be half-way between the peak of the start and space signals. The slice level for distinguishing between space and mark signals is adjusted to be half-way between the peaks of these signals. Therefore, a sudden increase in net loss greater than 1.8 db will result in the loss of start impulses, since they will be detected as space signals. A sudden decrease in net loss greater than 2.2 db, on the other hand, will cause space signals to be detected as start signals. Similarly, a sudden increase in net loss greater than 3 db will cause spaces to be detected as marks, and a sudden decrease in net loss greater than 5 db will cause marks to be detected as spaces. Any sudden change in net loss, even if it is less than these theoretical limits, reduces the allowable signal-to-noise ratio.

Perhaps the more difficult and costly circuit treatment is that of noise reduction. Noise of the impulse type, such as that caused by atmospheric static and switching transients in the telephone plant, can cause errors in data transmission, even though it is of such short duration as to be negligible in message transmission.

To reduce the noise caused by atmospheric static, it is necessary to limit the length of repeater sections. This provides a higher signal level at the carrier equipment terminals, and hence a higher signal-to-noise ratio. To reduce the noise caused by switching transients to a satisfactory level, it has been found necessary in many cases where the O, N, or ON carrier terminals or repeaters are located in dial offices, to provide a separate entrance cable for those facilities carrying the SAGE data signal. Use of a separate entrance cable reduces the noise induced by coupling between the cable pairs carrying the SAGE data signal and those carrying normal message traffic.

To test and maintain the operating units of the A1 system as well as the circuits used with this system, several units of specialized test equipment had to be provided. These include a "word generator" that was developed to provide simulated data-input signals, a "parity-check" circuit that provides an indication of the error rate on a circuit that is in service, and a "matching and error" circuit that is used to measure the actual error rate during maintenance periods and initial installation.

At the present time, the A1 system is being tested in a trial installation. These trial facilities are being used to transmit signals from several different types of radar stations to a model of one of the large computers. Results of the trial to date have indicated that the A1 system provides satisfactory transmission of the SAGE data signal, and is compatible with the data-generating devices and the computer input.

THE AUTHOR

A. E. Ruppel, a native of Brooklyn, N. Y., joined Bell Laboratories in 1935, and was concerned initially with the investigation of speech transmission over wire line networks and telephone instruments. He received a B.S. in E.E. from Brooklyn Polytechnic Institute in 1945 and the degree of E.E. in 1947. During World War II he engaged in a project for the NDRC, and later began a study of visual speech and an investigation of the production of complex-wave spectrograms. From 1947 to 1952, Mr. Ruppel was concerned with the systems engineering of mobile radio telephone systems, and in 1952 he aided in tests of over-the-horizon microwave radio transmission. From 1952 to 1955, he was engaged in the systems planning and initial trial of the DEW Line. Since then, he has been in charge of a group doing systems engineering on data circuits and facsimile services. Mr. Ruppel is a member of Sigma Xi, Eta Kappa Nu, and Tau Beta Pi.

Novel Sources of Electric Power

W. A. MARRISON
Transmission Research

The increasing use of transistors and other semiconductor devices in the Bell System is making it possible to perform many operations with very small amounts of power. Since it may be feasible to supply this power through the use of sources that might now be considered unconventional, the Laboratories has been investigating a number of small generators. One or more of these experimental sources might be suitable for applications such as use in rural telephone carrier systems.

Many circuits such as amplifiers and modulators now use transistors, and hence require only small amounts of power. This has created a demand for improved small power generators suitable for use in new communication systems. One example of this need is the rural carrier system in which it is necessary to provide about one watt of power in regions often remote from commercial supplies. In this and similar systems, the cost of supplying power by conventional means is an important factor which must be considered.

With this general problem in mind, a study was begun at the Laboratories a few years ago to investigate new methods for producing small amounts of electric power from various energy sources which might be reliable and eventually inexpensive. A great many possibilities were considered, including solar radiation, the wind, atomic energy, cold combustion, atmospheric electricity and heat from various fuels. Solar power, for example, can be used in many ways such as by collecting heat to operate thermopiles or heat engines, or by the direct photoelectric effect, as in the Bell Solar Battery.*

A new type of wind-operated generator, shown in Figure 1, has some interesting possibilities, because of its reliability and the extremely small amount of servicing required for its operation. The first model has been on trial for over three years and it is believed that it should run for ten years or more with no servicing whatever. A novel feature of its construction is that it has only one moving part, which revolves on a vertical shaft.

The rotor of the wind turbine rotates within a set of stationary blades which direct wind into the rotor blades. A permanent-magnet generator, with moving magnet and stationary windings, is mounted on the same shaft. The drawings in Figure 2 show the arrangement of parts and indicate the method of operation.

Wind blowing from any direction is directed against the rotor blades on the entering side, thus producing a counter-clockwise torque on the moving system. The air velocity is increased by the funneling action of the stationary blades. As it sweeps across the interior of the rotor, with changed direction the air produces additional torque in the same rotation sense on leaving the rotor. It is then carried away in the reduced pressure region at the rear.

The vertical symmetry of this windmill makes it independent of wind direction. It is not affected by gusty conditions including even large and rapid changes in direction. Since no mechanism is required to follow wind direction, there is a considerable saving in parts and maintenance.

* Record, *July*, 1955, *page* 241.

The output of the generator is alternating current with a frequency 30 times the rotation speed. This current is rectified and supplied to the load. A storage battery is connected in parallel to provide filtering and voltage regulation, to absorb excess power during high winds and to insure continuity of output during periods of low wind speed.

The total power contained in the wind at sea level is a little over 15 watts per square foot at 15 miles per hour. This varies as the *cube* of the velocity; at 6 miles per hour the total power is only about one watt, and at 60 miles per hour it is about a kilowatt. In many regions, a wide range of wind speeds is experienced. In the prototype mill, a novel method is used to obtain energy at low wind speeds without affecting the operation at high speeds. As shown in Figure 3, a tuned circuit, consisting of capacitor C and inductor L, is used to resonate the generator output at the lowest wind speed worth considering, in this case about 8 miles per hour. As the wind speed increases toward this value, the voltage across the inductor builds up to the amount that will cause some current to be delivered into the load circuit at the battery voltage. With increasing wind speed, the current delivered increases, thus imposing a resistance load across the inductor. This lowers the effective inductance and raises the resonant frequency to match the increasing frequency of the generator. This action continues with increasing wind speed until the generator voltage is high enough to deliver power without benefit of the tuned circuit. At high speeds, the reactive elements are inoperative because the impedance of the capacitor becomes low and that of the inductor becomes high with increasing frequency.

***Fig. 1** — A new form of windmill having only one moving part was mounted above tree top level in the Microwave Tower at Murray Hill. Later it was moved to the Outside Plant Laboratory at Chester.*

The model windmill has an effective cross section of about one square foot and, with an average wind speed of 11 miles per hour, produces an average power of one watt. Since the power in the wind varies as the cube of the velocity, the output into the battery is considerable at high wind speeds. At the Chester Outside Plant Laboratory, where the new windmill is now operating experimentally, the average wind speed is about 11 miles per hour.

More efficient wind-operated power supplies could be constructed in large sizes along the lines of the prototype model and, if operated at windy sites, would generate substantial amounts of power. Equipped with induction generators, such wind

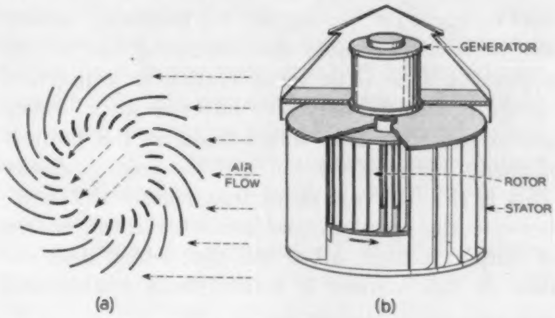


***Fig. 2** — (a) Wind entering the stationary blades from any direction follows the path indicated by the arrows and produces driving torque on both sides of the rotor; (b) the vane structure is open below, allowing drifting snow to fall freely through.*

machines could be used to deliver power into existing ac networks.

Another development which has considerable promise, especially for small-power applications, is the use of thermoelectric generators operated from fuel such as liquified petroleum gases. A tubular steel telephone pole within which is mounted a one-watt thermoelectric generator complete with fuel storage for many months of continuous operation is shown in Figure 4. The one-watt value was chosen initially because that is about the amount of power required for rural carrier repeaters. Either more or less power could be provided by simple design changes. Power poles such as shown could be used in pole lines requiring low power repeaters.

In a closed circuit composed of two different metals, if the junctions are maintained at different temperatures, an electromotive force is generated which causes current to flow. If a resistance load is included in the circuit, some useful power is delivered into it. When pure metals are used, this thermoelectromotive force is very small. With the

use of certain alloys of metals such as copper, nickel, chromium, gold and palladium, however, the effect is greatly increased. The thermoelectromotive force obtained with chromel-p (90% Cr–10% Ni) and constantan (60% Cu–40% Ni) is about 75 microvolts per degree centigrade difference in temperature per couple. These materials with good heat resistant properties have been used in most of the studies on thermoelectric generators at the Laboratories. Any desired output voltage can be obtained by connecting a sufficient number of couples in series. The maximum power is delivered from any given combination of elements when the load resistance is very nearly equal to the internal generator resistance.

It is important that the best possible use of the fuel be made for heating the hot junctions, consistent with a reasonable manufacturing cost of the apparatus. One basic consideration in a practical design is that the only heat effective in producing useful power is that which flows in the thermoelements between the hot and the cold junctions. This is the only source of temperature difference between the junctions, and hence is the only source of output voltage. All of the heat which does not flow in this manner is wasted, and a successful design is one which reduces this waste to a minimum. As a result of numerous experiments and careful design, it is now possible to use more than half of the heat of combustion of a fuel and hence to obtain an efficiency of operation in excess of half of the theoretical maximum for a given combination of thermoelements. In a larger device this ratio could be somewhat increased.

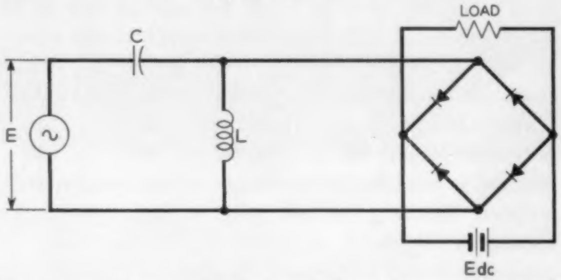


Fig. 3 — Electrical circuit used with experimental generator operated by wind power.

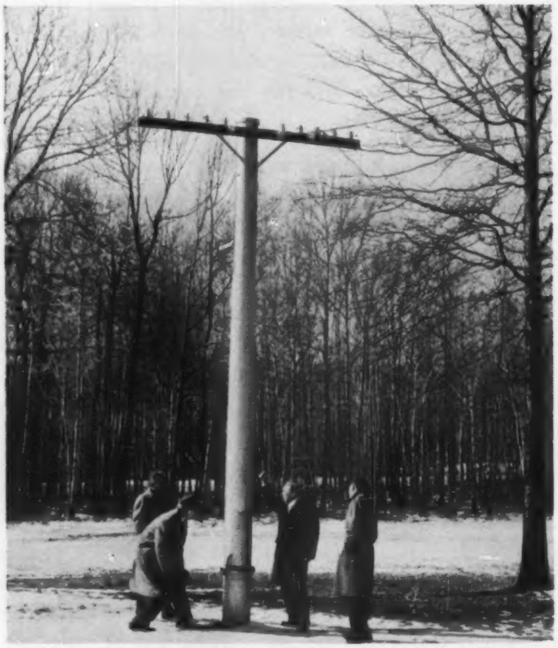


Fig. 4 — This telephone pole is hollow and contains a thermoelectric generator of one-watt capacity powering a transistor amplifier. The lower portion of the pole is a storage tank for "bottled gas" used to operate the generator.

The design of a suitable burner is of utmost importance so that *all* of the fuel will be consumed without the need for excess air. Fuel that is not burned, and excess air that is heated, represent irretrievable losses. The burner must also be designed so that the heat produced is distributed in a satisfactory manner among the hot junctions. If some junctions are too hot, their useful life will be shortened. If some are not hot enough, on the other hand, they do not contribute their share to the total output. Much effort has been expended on the design of a long-life burner which provides complete combustion and a satisfactory distribution of heat.

The supporting structure is of equal importance because any heat which is bypassed through it, instead of going through the thermoelectric material, is completely lost. The supporting material should be as good a thermal insulator as can be obtained with the required structural strength. A new material is used in the latest design. It is composed chiefly of the ash of rice hulls and can be moulded in intricate shapes. Rice-hull ash is about 96 per cent pure silica in porous form similar to that in diatomaceous earth and makes an excellent thermal insulator.

The thermoelectric generator is constructed by first weaving alternate wires of chromel-p and constantan into mats with a glass fiber warp as shown in the illustration on page 406. The ends are connected in zig-zag fashion, resulting in a number of thermocouples connected in series. The connections are made mechanically secure by twisting the ends protruding from the mats. One of the completed

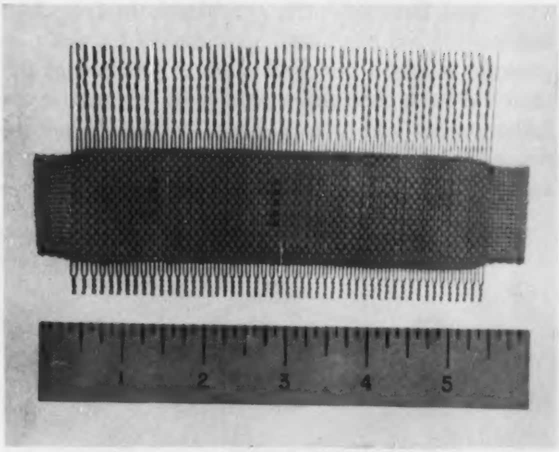


Fig. 5 — After being woven into mats the projecting ends are twisted to form mechanically strong connections. This operation joins all of the thermocouple pairs in series.

mats with twisted connections is shown in Figure 5.

A thick layer of nickel is electroplated on the short twists which become the hot junctions, and a thick layer of copper is plated on the long twists which become the cold junctions. This plating operation is shown in Figure 7. Electroplating produces excellent electrical connections which appear to be superior to the welded junctions used in earlier experiments. Nickel is highly resistant to corrosion of the hot junctions, and the copper, because of its high thermal conductivity, aids materially in the dissipation of heat from the cold junctions.

If a number of thermocouples made from the same materials are connected in series, and if they are operated at different temperatures, the cross sections of the wires for the most effective use of the heat should be about inversely proportional to the temperatures. For this reason, wires of three different gauges are used in the construction of the thermocouple mats. In the final assembly, the thin wires are placed in the region of highest temperature near the active part of the burner. Progressively larger gauges are used farther from the burner where the temperature is reduced by the prior extraction of heat from the flue gases.

The relative cross sections of the two thermoelectric materials used is also an important consideration. With some pairs of materials a ratio as high as 50 to 1 must be used for best operation. In the case of chromel-p and constantan, however, the best ratio is nearly unity.

To complete the generator, a number of mats as described are assembled with insulating spacers in a cylindrical arrangement such that all of the hot junctions face inward enclosing a tubular space about one inch in diameter. The burner is enclosed in this space so that most of the available heat is collected by the nickel-plated twists and flows outward to the long copper-plated twists where it is carried away by convection. A complete 25-volt 1.25-watt unit, suitable for installation in a power pole, is shown in Figure 6.

From severe laboratory tests made on each essential part, it is estimated that generators of this type may be operated continuously for ten years or more. The only servicing required is to supply fuel at infrequent intervals. In the thermoelectric power pole now on continuous test, the lower portion, including that below the ground level, is a fuel storage tank. This can be filled with "bottled gas" on a routine basis in the same way that household supplies are delivered in many communities. The difference in this case is that filling is required only about once a year. Of course, this interval depends upon relative dimensions and may be designed for any specified requirement.

The generator is mounted within the pole above the fuel tank and continues to deliver power as long

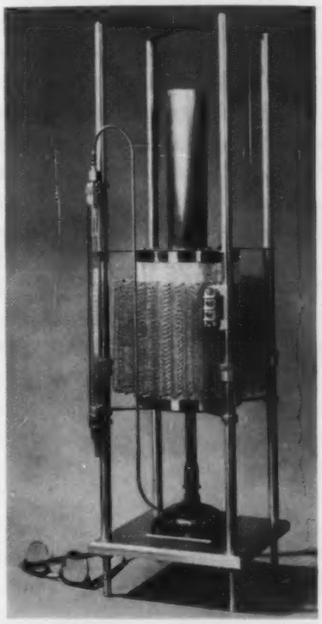


Fig. 6 — Latest design of thermoelectric generator to produce 1.25 watts at 25 volts for use in a power pole. The gauge at the left measures the gas flow, which is 4 cc per second.

as fuel is supplied. The rate of burning is quite low; the heat required is only a little more than that produced by an ordinary candle. In the present working model, one watt of power is delivered at 20 volts. However, this is a matter of the design of the thermoelements and a considerable range of power

and voltages may be obtained readily. Also, various voltages, with or without common connections, may be obtained by special grouping of the thermoelements in the mat structure.

Advantages of this type of power supply are that it has no moving parts and it is absolutely quiet in operation. In addition, relatively noise-free direct current is delivered at the desired voltage. No voltage conversion or filtering equipment is required, and for constant load operation, no electrical storage is needed. However, for applications where relatively large power surges are required for any purpose, such as for signaling, a storage battery may be connected across the generator.

The prototype power pole is being monitored continuously through the use of a transistor amplifier which also is mounted within the pole. Circuits from the pole to the laboratory have been installed for making tests on the generator and on the amplifier. The output voltage of the generator is recorded continuously by a strip-chart meter.

The weaving and electroplating involved in the construction of generators as described are rather time consuming when done by hand. However, these operations could be performed by automatic devices if there is a suitable demand. Since the cost of materials is low, it should be possible in this way to construct reliable and convenient power sources of small capacity for many applications.

Experiments are in progress on the use of thermoelectric materials other than alloys of the pure metals. It has long been known that some combinations of certain materials such as zinc, antimony, bismuth and tellurium have relatively large thermal electromotive forces and that they should make very good thermoelectric generators. In fact, zinc-antimonide has been used sporadically for this purpose for nearly a hundred years. A junction of this material with constantan is now on life test at the Laboratories and a new generator based on the results is in the course of construction. This generator is expected to deliver more power with greater

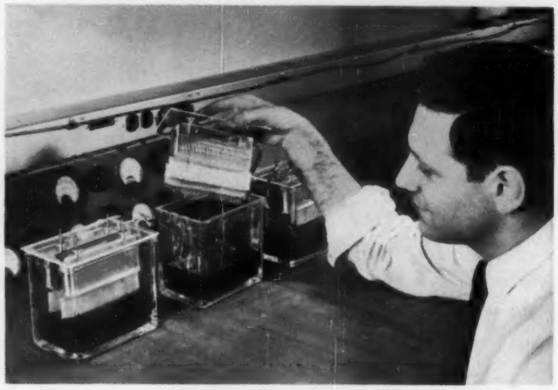


Fig. 7 — B. D. Alexander electroplates nickel and copper over ends for permanent electrical contact.

efficiency than can be obtained with the materials currently used.

Plans have also been made to investigate the use of certain oxides, carbides and sulfides, as well as n- and p-type silicon and germanium, which have desirable thermoelectric properties. For this type of application, however, most of these materials would be costly or difficult to fabricate, or both. The problems of constructing suitable forms, and establishing good electrical contacts, especially at the hot junctions, are considerable, but the inherent advantages demand continued effort.

THE AUTHOR

W. A. Marrison received the B.S. degree from Queens University in Ontario, from which he also holds an honorary D.Sc. degree. He received his master's degree from Harvard. He joined the Western Electric Company in 1920 and was associated with the Research Department of the Laboratories since its formation in 1925. Among his many contributions in the field of constant-frequency sources of alternating current, he pioneered in the development of quartz crystal oscillators as precision standards of time. For this work, he was awarded the Tompian Medal and the Gold Medal of the British Horological Institute. He is a fellow of the British Horological Institute and the American Association for the Advancement of Science, senior member of the I.R.E., a member of the A.I.E.E., the American Physical Society and the American Geophysical Union. Mr. Marrison retired from the Laboratories in June of this year.

Polyethylene Bonded with New Process

Henry Peters testing tensile strength of new polyethylene bonds to brass and rubber compounds.

With a new bonding process recently announced by Bell Laboratories, polyethylene can now be satisfactorily joined directly to brass and brass-plated metals, and to natural and some synthetic rubbers. The process, developed by Henry Peters of the Chemical Research Department (cover photograph), produces a bond many times stronger than any currently used for this purpose.

Polyethylene is the familiar plastic used for food wrappings and many household utensils. Also widely used in industry, one of its principal applications is its use as a cable-sheath material. For many years, however, industry has needed a strong adhesive for polyethylene – a need that is fulfilled by the new process. It produces bonds with tensile strengths up to 1000 pounds per square inch and peel strengths as much as 100 pounds per inch. These values are considerably higher than have been possible with previously available techniques.

Intermediate Layer

The process makes use of the product known as Hydropol (partly hydrogenated polybutadiene) manufactured experimentally by the Phillips Petroleum Co. of Bartlesville, Okla. Degrees of unsaturation of the polybutadiene between 3 and 30 per cent give the best bonds. Various materials are added to the Hydropol to make it capable of vulcanization. Apparently the hydrogenated polybutadiene adheres to the polyethylene because of its thermoplastic properties and similar chemical structure. The bond to a vulcanizable rubber is probably due to the formation of sulphur crosslinks at the interface that occur during vulcanization.

A layer of bonding agent 2 to 3 mils thick is desirable for proper adhesion. The agent may be made up in a solution and sprayed, brushed, or dipped to provide the desired layer, or a thin sheet can be fabricated and inserted between the materials to be bonded.

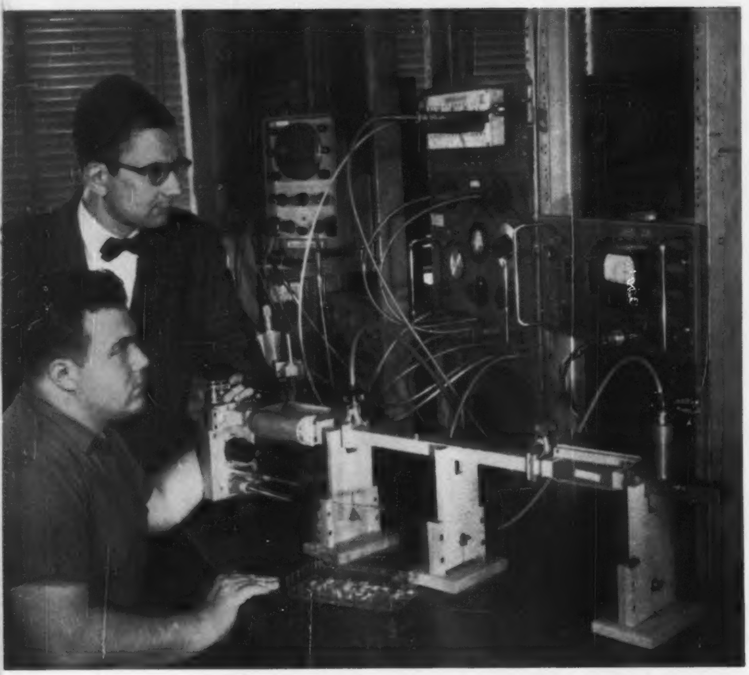
Bonding is accomplished at temperatures ranging from 250 to 350 degrees F and at pressures of 100 pounds per square inch or less, although higher temperatures and pressures may be used. The process may be extended to other plastics related to polyethylene.

Applications

More than 550 million pounds of polyethylene were produced last year. Industry experts estimate that it will become the first billion-pound-a-year plastic and that this level of production may be reached by 1960. It is expected that the bonding agent will greatly increase the applications of polyethylene products.

The bonding agent will be of considerable value to the Bell Telephone System and to the plastics and rubber industries. Some of its major applications may be the bonding of insulation to conductors in plastic "drop wire" used to extend telephone service from the line to the home, and the bonding of polyethylene to brass in submarine repeaters for underwater telephone cables. Other significant uses may be the bonding of linings to tanks and the bonding of polyethylene coatings on plating racks or wherever else they are needed. The process will protect metals from corrosion since the polyethylene can be fixed directly upon the metal without the use of intermediate material other than the adhesive.

The need for such an adhesive has been particularly apparent in such communication equipment as undersea telephone cables, which must be constructed to resist both pressure and water. To bond natural rubber to polyethylene in these cables, it has been necessary to use four intermediate layers of polyethylene and natural rubber mixtures. This complex bonding process can now be eliminated since the new process requires only the adhesive to join rubber and polyethylene.



Semiconductor Diodes Yield Converter Gain

A. Uhlir, Jr., (top) and N. Bronstein test diode modulator used in TH microwave system.

Useful amplification in a semiconductor-diode converter stage has been proven feasible at Bell Laboratories. Working with gold-bonded germanium diodes and with diffused p-n junction silicon diodes, A. Uhlir, Jr. and A. E. Bakanowski of Bell Laboratories have achieved significant amounts of gain both in "up-converter" and "down-converter" stages of electronic circuits.

Most promising results to date have been obtained with the up-converter, in which a low frequency is converted to a higher frequency. Gains as high as 6 db with adequate bandwidth for most applications have been achieved with gold-bonded germanium diodes when converting from 75 mc to 6000 mc. Such a converter stage is useful as a modulator for a microwave transmitter. These up-converter amplifiers are essentially unilateral – that is, they do not amplify in the reverse direction. Thus, an amplifier stage employing such a converter is very stable.

With the diffusion process developed at the Laboratories, diffused silicon p-n diodes exhibit conversion gain and are usable at higher temperatures than germanium diodes.

An outstanding feature of the up-converter diodes is that they can be made with relatively large active areas, thus greatly increasing their power-handling capacity over that of conventional point-contact converters.

The new TH microwave radio relay system recently announced by Bell Laboratories employs gold-bonded germanium diode up-converters. One application is the transmitting modulator, used to convert the intermediate frequency (60 to 90 mc) to the frequency of the final output (various frequencies in the 6-kmc common-carrier band). This stage is operated at zero gain to provide the required bandwidth (10 mc ± 0.05 db).

Other up-converter stages combine amplified harmonics of a highly stable crystal oscillator to give the various desired carrier frequencies in the 5925 to 6425 mc band. Since bandwidth is not a problem in this application, up to 10 db of gain is realized. These represent the first practical applications of diode converters in which there is no loss of signal in the converter stage.

Conversion gains as high as 45 db have been achieved in down-converters using diffused silicon diodes. Also, M. E. Hines of the Laboratories has demonstrated a negative-resistance diode amplifier operating at 6000 mc. Such amplifiers and down-converters in general are regenerative – that is, there is poor isolation between input and output. In the past, this has limited their usefulness, but the availability of non-reciprocal ferrite devices may improve considerably the feasibility of regenerative operation of diode amplifiers and amplifying down-converters.

Having the best telephone equipment in the world is not the whole answer to providing good telephone service. Equally important is how, when and where the equipment is to be used — in other words, the traffic conditions under which each central office operates. The Laboratories has for some time conducted traffic studies and has designed various types of traffic-measuring equipment as an aid to Operating Company engineers in making the best use of dial office equipment and trunking facilities.

Traffic-Usage Measuring: The Key to Dial Office Engineering

M. F. MORSE *Traffic Studies*

Traffic engineering and dial-office administration are two major aspects of the telephone business that depend directly on the availability of adequate data concerning telephone traffic. The adequacy of such data can, in general, best be met by a single standard measurement – traffic usage. This measurement combines the number of calls in a given period with the length of time for each call. To understand how traffic-usage measurements can assist the traffic engineer in making the best use of the plant for which he is responsible, let us consider the nature of his job. Briefly, it is logistics. The traffic engineer's duty is to see that facilities of the *right kind* are in the *right place* at the *right time* and in the *right amounts* to give high quality telephone service to all customers.

Required quantities of equipment and trunks and the resulting grade of service are mutually dependent upon traffic densities; determining the nature of these relationships involves application of the laws of probabilities. Probability studies and traffic research carried on by the Laboratories* provide the basis for "capacity tables" published by the A.T.&T. Company for use by the Operating Companies. The quantities of trunks, switching equipment and common control devices required in a dial office are determined from the appropriate tables.

Obviously, the capacity of telephone equipment must be related to the maximum load it will have to handle, so the traffic engineer is principally interested in the traffic during the hour of greatest usage each day, generally known as the busy hour. In most cases, capacities are expressed in terms of CCS (hundred call-seconds). This is an expression of the telephone service a group of facilities is capable of providing for one hour at an acceptable level. This measure of usage (or traffic load, as it is frequently called) involves two factors: the volume of calls and the elapsed time each call occupies the facilities, commonly referred to as "holding-time". A single communication channel will be kept fully occupied for one hour whether it handles one call lasting 3,600 seconds, 36 calls lasting an average of 100 seconds, or sixty calls averaging one minute. Of course, it would not be practical to design a telephone system with the objective of having all channels fully occupied, even during the busiest

* Record, *April,* 1955, *page* 125.

Fig. 1 — Miss Edna Lazarns, left, and Miss Florence Gorman of the Laboratories record at regular intervals the number of switches engaged with calls. This "switch count" procedure is still widely used to determine usage of dial equipment.

hour. To have at least one call ready the instant an opening becomes available, a backlog of waiting calls must exist. Delays in making connections brought about by the build-up of a large backlog, however, would be intolerable. Capacity tables, therefore, are needed to relate the expectancy of delay to the various degrees of load that might be presented to a given number of channels.

To estimate equipment requirements, the traffic engineer must predict the busy-hour usage for each group of facilities in each dial office and for the related trunks at some future date, perhaps two to three years away, when these facilities have been installed and when the growth for which they were provided has been attained. Within an office, traffic is generally split into distinct channels to provide the special switching features required by different classes of service and to conform to the specified routing pattern. Each segment of traffic may have its own busy hour, so that engineering data are required for each distinct class, as well as busy-hour data for all office equipment used in common. Thus, separate load estimates for many different groups in the dial system will be needed. Usually the traffic engineer makes an estimate based upon some knowledge of past usage, and then increases this estimate in proportion to the anticipated growth in telephone service. In most cases, heretofore, such usage data might be termed synthetic since it was calculated from independent measurements of call volumes and holding-times.

Obtaining call volumes is one of the simplest means of measuring traffic. It is common practice in the Operating Companies to designate two days each month for making an hourly count of the calls handled by various portions of the equipment in each office by reading traffic registers connected to the equipment. These records are called "peg-counts", from the early method of keeping a count of calls handled at switchboards. Figure 2 compares data obtained on scheduled peg-count days with a special record of busy-hour calls for each business day during a full year. As seen from this comparison, the peg-count system fails to provide data on many of the peak hours, but over a long enough period it gives a good approximation of average call volumes during the busy-hour.

Equipment usage, however, depends not only on the number of calls, but also on the average holding-time per call. The determination of holding-time is difficult. Either the duration of individual connections must be measured, or a count of the

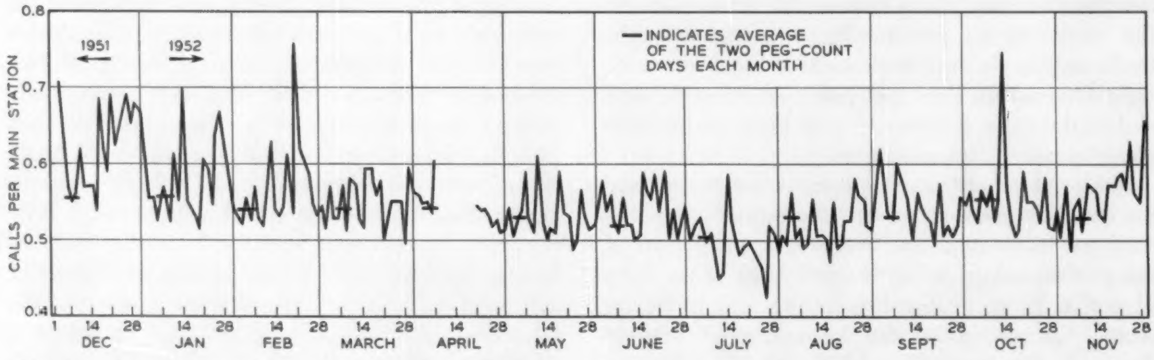


Fig. 2 — Calling rate at the busy hour for a one-year period compared with the average rate for the two peg-count days of each month. Peg-count system is inadequate for many of the peak hours.

number of switches in use may be made at intervals frequent enough to establish the average hourly usage; the holding-time may then be derived if the number of calls handled is known. These two methods of obtaining holding-time data are shown in the illustration on page 411 and Figure 1, respectively. The first method is practical only for extremely small samples, while the latter requires a sizable clerical force. Holding-time records, consequently, usually are too short and infrequent to be well correlated with calling-rate fluctuations.

Because the traffic load in CCS is of major interest in the engineering of dial offices, a logical step was to design a traffic-measuring device for gathering usage data directly. The traffic-usage recorder*, developed at the Laboratories, provides the traffic engineer with a greater volume of data, at greater speed, and with greater accuracy than was possible with earlier methods. With the traffic-usage recorder, daily usage records become practical since they are low in cost and need not be examined in detail unless attendant circumstances indicate such analysis is desirable. Because usage may be measured simultaneously for all channels of an office, the desired average level of usage may be obtained in a comparatively few busy hours. This is in sharp contrast to the weeks needed to complete a reasonable sample of traffic usage on the same facilities with holding-time or usage-sampling devices.

The direct measurement of usage overcomes errors inherent in the old method. Previously, records of call volumes were taken at one period, and holding-times were recorded at some other time and, very likely, under different conditions. As a matter of fact, from the standpoint of equipment usage, the busy hour as selected from peg-count records of call volumes may not be the true busy hour. The average holding-time will be affected by variations in conversation times from hour to hour, as well as by variations in the number of attempts that find the called number busy or all switching paths busy. These attempts contribute relatively little to the usage of equipment, even though they enter into the count of calls.

A comparison of usage and peg-count data is furnished in Figure 3, which shows the results of busy-hour studies made in one office each business day for about four months. The graphs of calling rate and usage represent the values actually measured each busy hour, while the holding-times indicated have been calculated from these data. These results indicate that, in this instance, usage shows a considerably smaller per cent variation than calling-rate. Since holding-times are also subject to variation, it follows that usage measurements will furnish a more reliable estimate of the load than an equal amount of call-rate data combined with an average holding-time measured at random.

In the present study, the average busy season (February through April) calling-rate was established by daily measurement. These data, even if combined with a holding-time based on a typical two-week measurement from February 28 through

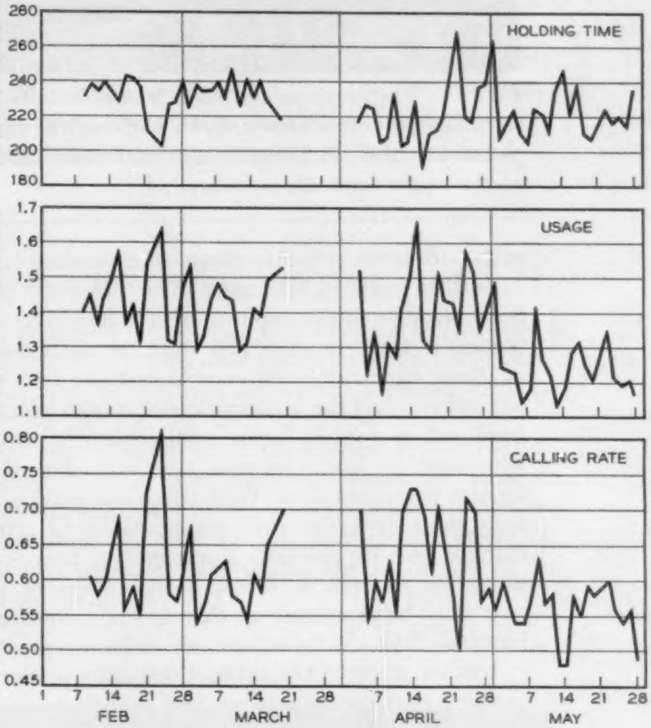


Fig. 3 — Holding-time, calling-rate and usage for a typical busy season, plotted together to show the interrelationship of these usage measurements.

March 11, would give a misleading result. Combining these calling-rate figures with the typical holding-times would mean providing four per cent more equipment than would be indicated by the average directly measured usage for the same period. It is also worth noting that a comparison of the calling-rate and holding-time graphs shows that frequently a peak in the former is matched by a valley in the latter. This condition might be expected if a substantial part of the peak traffic encounters busy lines or busy switching paths. Interpretation of such peaks is difficult when a

* RECORD, *September*, 1954, *page* 328.

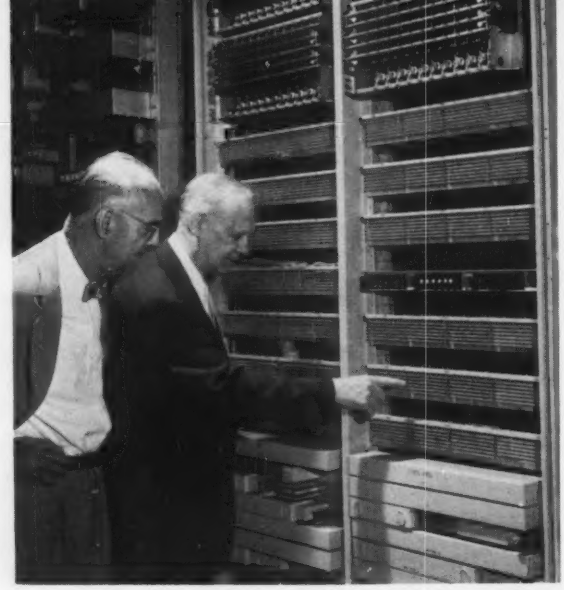


Fig. 4 — Traffic-usage recorder frame installation in the crossbar laboratory. C. H. McCandless, right, points out to W. B. Strickler where the connections to the traffic registers are installed.

peg count is the principal means of estimating load.

Further gains in telephone plant efficiency may be realized from the application of traffic-usage recorders in traffic engineering. With the older method, there is a natural tendency to estimate both the call volume and the holding-time at a high average level, just as a safety factor, and frequently further allowances are made for peak days not reflected in regular peg-count data. With usage recorded on a daily basis, however, such compounding of safety margins will be avoided. Furthermore, busy-hour usage for the ten or fifteen busiest days of the year may be examined, so that special allowances for peak days can be adequately determined.

Another phase of Operating Company operations to which usage measurements will contribute greatly is in the field of dial office administration. This might be described as "current" engineering, in contrast to the type of traffic engineering which deals primarily with provision of equipment for the future. The administrative group must see that available equipment is properly loaded, so that the number of customers for which it was designed may be connected and a satisfactory grade of service for all customers maintained. To attain these objectives, the total load must be properly distributed among the frames and subgroups of equipment to maintain a proper balance of usage between the various channels through an office.

Dial office administration generally has depended on a variety of indirect indicators of load conditions to assist in load balancing. Such indicators vary from system to system and include registrations of overflow, all trunks busy, last trunk busy, delay, or minimum percentage of paths found busy. These indicators function on a "per call" or "per occurrence" basis and in general give no weight to the time factor. Thus, they fail to give a positive load value, and in addition require a considerable amount of effort to interpret them in the light of other related conditions. Traffic-usage measurements, on the other hand, point directly to the spots where attention is needed and furnish a quantitative basis for gauging the required adjustments.

In the past, a difficult problem in balancing loads was the selection of customers lines to be distributed among equipment groups, since little prior knowledge was available concerning the usage of particular lines. Consequently, the selection was frequently random, which made a large proportion of the effort ineffectual. Often, because of the dubious success of these line-moving attempts and the sparsity of usage data available, too little attention may have been given to maintaining load balance. For example, in crossbar offices the access of each line to the office for both originating and terminating service is limited to ten paths used in common by the 19

THE AUTHOR

M. F. Morse, a native of Gardiner, Maine, received the B.S. degree in Electrical Engineering from the University of Maine in 1929, and in the same year began his Bell System service in the Long Island Area of the New York Telephone Co. After several years' experience in central office maintenance, he became a chief switchman, and in 1944 transferred to traffic engineering. Later, as supervising engineer, he was responsible for the preparation of traffic orders for panel and crossbar dial office equipment. Since joining the Bell Laboratories staff in 1953, he has been engaged in the engineering aspects of traffic measurement facilities, particularly traffic-usage recorders and their application to the several types of dial system offices.

to 69 lines in a group.* Thus, a few heavy users can have a large influence upon the whole group. Usage measurements are the only practical means not only of frequent checking for unbalanced groups (some loaded beyond capacity and others lightly loaded), but also of determining the lines to be moved to correct the condition with a minimum expenditure of time and effort. In fact, with group usage data available to establish initial balance and to guide the assignment of new customers, fewer occasions will probably arise necessitating line transfers.

The Laboratories has developed a traffic-usage recorder for permanent installation in the various types of dial system offices, and many installations are already in service. Figure 4 gives some idea of the size of such installations. Traffic register cameras are also available to photograph automatically the register readings at scheduled intervals.

* RECORD, *March*, 1939, *page* 219.

A portable usage recorder has also been designed for small community dial offices where the permanent type of installation may not be justified. These developments are all aimed at making adequate and reliable usage data readily available to traffic engineering and administrative personnel.

The present Bell System investment in dial-office equipment – both local and toll equipment and the associated trunk plant – amounts to several billion dollars. Considering the magnitude of this investment, it is essential that full use be made of existing facilities, and that strict economy be exercised in providing new plant. If, through better traffic data, savings of as little as ½ of one per cent can be made, the reduction in plant investment will be considerable. With widespread application of traffic-usage recorders, and further economies from mechanization of data processing, savings in the order of two per cent may be utilimately realized.

Tin-Germanium Study Proves Research Theory

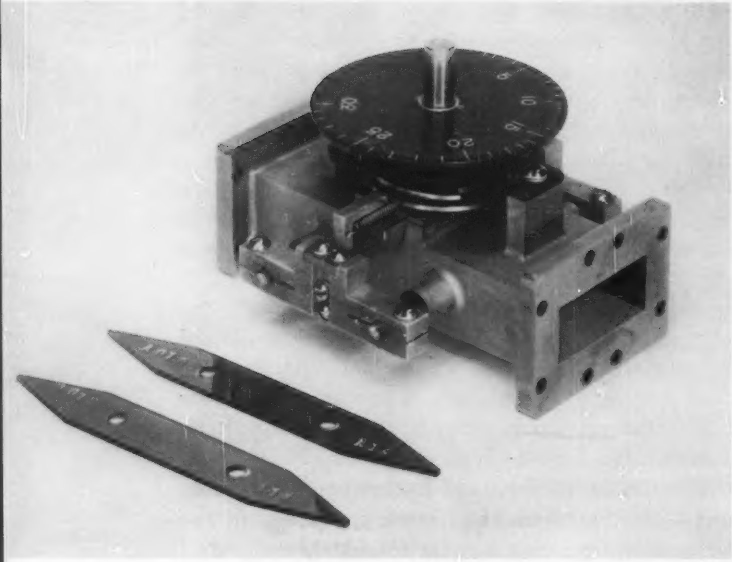
Semiconductor materials in general are extremely sensitive to the presence of impurities. It has long been theorized, however, that impurities with the same number of valence electrons as germanium would be neutral – that is, they would act as neither donors nor acceptors if present in germanium. The theory has been verified with experimental evidence recently obtained by F. A. Trumbore of the Laboratories.

Working with tin and germanium, both of which had been highly purified by Bell Laboratories' zone refining process, Mr. Trumbore was able to obtain single crystals of germanium containing tin at concentrations greater than 10^{19} to 10^{20} atoms per cubic centimeter. These crystals exhibited room-temperature resistivities of 30 to 50 ohm-centimeters, practically the same as ultrapure germanium, thus proving that the tin did not significantly alter the electrical characteristics of the germanium. The long lifetimes in these crystals, as high as 100 to 200 microseconds, also indicate that tin atoms definitely are not effective recombination centers.

Germanium crystals containing several hundredths of an atom per cent tin were grown by the pulling technique from melts containing the appropriate percentage of tin. For a higher tin concentration, a process was used which takes advantage of the fact that the solubility of germanium in molten tin increases with temperature. Germanium is dissolved in tin at a given temperature and precipitated or grown on a seed crystal at a lower temperature, which may be several hundred degrees below the melting point of germanium.

Chemical analysis of the crystals grown by the latter method, after dissolving excess tin, showed a solid solubility of tin in germanium as high as one atom per cent. Precise x-ray measurements of lattice constant showed that the tin is indeed in solid solution.

In studies of tin in germanium, F. A. Trumbore inserts germanium sample in oven.



An Improved Microwave Attenuator for Military Use

In microwave equipment, it is frequently necessary to adjust signal strength within a waveguide. These adjustments are commonly made with attenuators that incorporate small vanes or fins, which are movable in such a manner that the farther a vane is inserted into the waveguide, the more microwave energy is absorbed. For Bell System radio-relay use, calibrated microwave attenuators have been developed with a range of 20 db.

Recently, these attenuators have been adapted for use in measuring circuits of the Nike missile project. The attenuators had to be made smaller in size, and the dimensions were accordingly scaled down for use at "x-band" frequencies (8.5 to 9.6 kmc) in the military application. In addition, a wider range of attenuation was necessary, and the attenuators had to be stable over a much wider temperature range.

As shown in the illustration above, the modified attenuator consists of two tapered vanes, each about three inches long, mounted in 1¼ by ⅝-inch waveguide. The two attenuating elements are inserted from the edge toward the center of the waveguide to increase attenuation. Insertion is controlled by two cams turned by a single calibrated dial, and the cam configuration is such that the two vanes are inserted at different rates. As a result, the attenuator provides nearly constant loss between 8.5 and 9.6 kmc with an almost linear dial scale.

Many different materials were tested for use as attenuating elements, but it was found that heat-resistant glass with a thin nichrome film resulted in the most stable and linear attenuation characteristic. At first, it did not seem desirable to use glass for the attenuator vanes, but shock tests were performed in which the vanes were subjected to forces up to 30G with no electrical or mechanical failures.

The attenuator is variable from 0.2 db to 30 db and, between 8.5 and 9.6 kmc, the actual attenuation is within 0.5 db of the dial indication. Even though such high attenuation is obtained in such a short length, the voltage-standing-wave-ratio (VSWR) between 8.5 and 9.6 kmc is no greater than 1.2 to 1 for attenuation of 30 db or less. This attenuator also has a good degree of stability, since attenuation is practically independent of temperature change between 10° and 175°F. In addition, changes in relative humidity from zero to 95 per cent result in attenuation changes which do not exceed 0.5 db at the maximum scale position. The unit is suitable for applications where a small, stable attenuator is desired and a very low VSWR is not essential.

The illustration at the top of this page shows a calibrated microwave attenuator adapted for military application. The two attenuator vanes, which are made of glass, are placed beside unit.

F. L. Rose
Military Communications Development

Full use of the transistor's size advantage calls for other miniaturized components which can be applied to an electronic circuit. A new type of charge-storing device, the tantalum solid electrolytic capacitor, has been developed at Bell Laboratories for use in transistorized circuits. It is a sturdy, compact unit which exhibits several advantages over conventional capacitors.

Miniaturized Tantalum Solid Electrolytic Capacitors

FLORENCE S. POWER *Component Development*

The new tantalum solid electrolytic capacitors, developed at Bell Laboratories, have several distinct advantages over conventional types. They store more charge per unit volume than any other capacitor. They have good shelf life and potentially high reliability. They maintain their properties at very low temperatures, and have relatively high Q, or performance, efficiency values at high frequencies. Also, where high capacitance is required, these electrolytic capacitors can provide more in a given space and at a lower cost per microfarad than any other type. Tantalum capacitors have been developed primarily for use in low-voltage transistorized circuits, and they are comparable in size to transistors themselves. They have also found considerable usefulness in other fields.

"Solid" electrolytic capacitors are a new departure in charge-storing components. They may be compared with their nearest relatives, the "wet" electrolytic capacitors which consist of a "sandwich": anode metal – metal oxide – aqueous electrolyte – cathode metal. The structure of the solid electrolytic capacitor is a slightly more complex sandwich: anode metal – metal oxide – solid electrolyte – carbon – cathode metal. The essential novelty in the latter type is replacement of the aqueous electrolyte by a solid semiconductor so that there is nothing to leak out, evaporate, freeze, or corrode the oxide or metal layers.

A schematic illustration of a porous tantalum solid electrolytic capacitor is shown in Figure 1. The solid electrolytic capacitor is built up, layer by layer, upon the anode member. This anode is composed of tantalum metal, in the convenient form of tiny particles sintered together at very high temperature, to produce a pellet of high porosity and consequently large surface area. Since capacitance

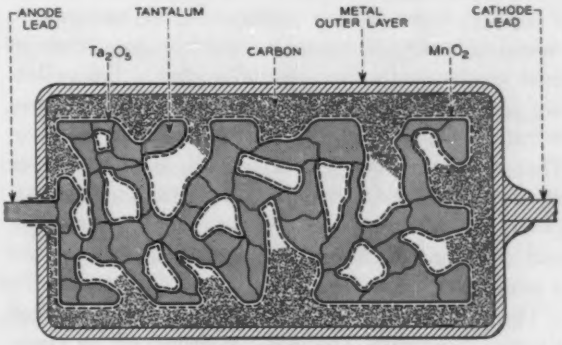


Fig. 1 — The porous tantalum anode provides a large surface area with resulting high capacitance.

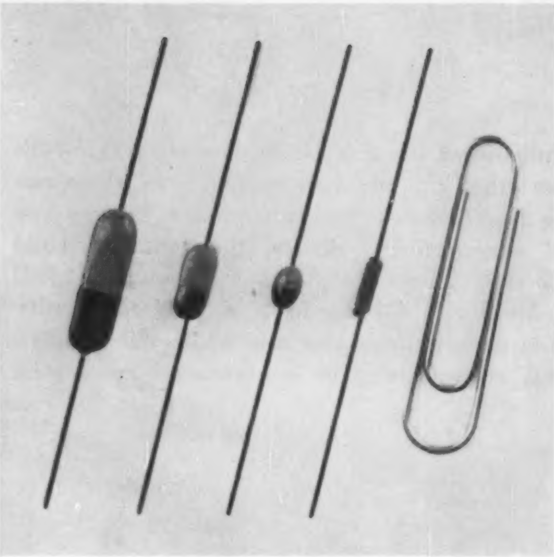


Fig. 2 — The tantalum capacitor is essentially a miniaturized component. The capacitor at right is the etched wire fractional microfarad type.

varies with the surface area, these porous pellets have extremely high capacitance for their size. An oxide film which acts as the dielectric in the completed capacitor is formed by placing the anode and a tantalum cathode in an electrolytic bath. Oxygen released from the water by the passage of current reacts with the porous tantalum pellet at the anode to build a layer of tantalum oxide (Ta_2O_5) of thickness proportional to the applied voltage. This thickness governs the capacitance per unit area and the allowable working voltage. The tantalum oxide layer is very thin, only a few thousand angstroms at most, and produces beautiful interference colors. Each 12-volt rise in formation voltage shows an individual spectral color.

The next ingredient added to the sandwich is a complete layer of the semiconductor manganese dioxide (MnO_2). Because it would be impossible to coat mechanically the internal surfaces, the pellets are saturated with a water solution of manganese nitrate ($Mn(NO_3)_2$) and then heated in a furnace. The water and NO_2 are driven off, leaving a layer of insoluble MnO_2 which (after the third coat), practically fills the pores. To get complete coverage and sufficient thickness, this treatment is repeated a number of times.

The next layer is carbon, which is applied from a water dispersion. The water is driven off by evaporation. On top of the carbon a final coating of metal is applied by a convenient and economical method which consists of spraying a coating of solder or other metal directly onto the carbon-coated pellet.

Attachment of a cathode terminal and a solderable anode lead completes the structure of the capacitor. Finish coats and code markings are added. Figure 2 is a photograph of typical capacitors, which may vary in capacitance from 0.02 to 100 mf.

Solid electrolytic capacitors have a temperature coefficient of +0.05 to +0.07 per cent change in capacitance per degree C over the temperature range from −75°C to +100°C. In contrast, wet electrolytic capacitors fall off sharply in capacitance at low temperatures because of congealing or freezing of the electrolyte. In circuits using solid electrolytic capacitors, the power factor also continues to be good at low temperature because relatively high conductivity in the MnO_2 electrolyte is maintained (see Figure 3(a).)

The outstanding improvement in temperature characteristics of solid over wet electrolytic capacitors is shown in Figure 3, in which relative capacitance and power factor values are plotted against temperature. This improvement can be il-

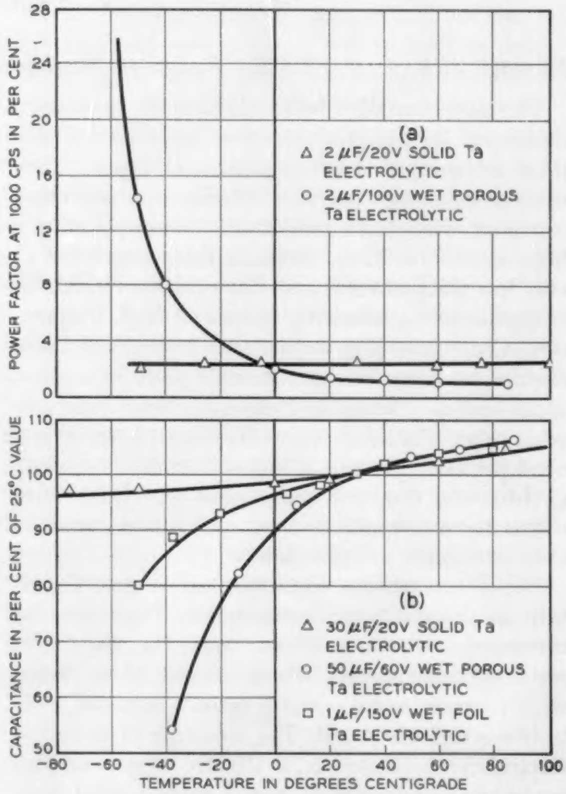


Fig. 3 — Solid electrolytic capacitors show improved characteristics over a wide temperature gradient.

lustrated in an interesting manner by inserting first a wet and then a solid tantalum electrolytic capacitor in an oscillator circuit. The audience listens to the tone produced as the temperature of each capacitor is reduced by packing it in powdered dry ice. With the wet electrolytic capacitor, the pitch of the signal rises rapidly with the decrease of temperature, and then fades out altogether. With the solid electrolytic capacitor, the tone continues strong and almost at the same pitch from room temperature down to —75°C.

The high-frequency characteristics of any electrolytic capacitor are controlled by the series resistance and series capacitance for which the electrolyte is responsible. Solid electrolytes are less limited with regard to frequency because of the relatively good conductivity of the semiconductor and its small thickness. If a capacitance maintained to high frequency is needed, it could be obtained more easily from a low-capacitance solid electrolytic capacitor than from a high-capacitance wet electrolytic capacitor. Both Table I and Figure 4 show this.

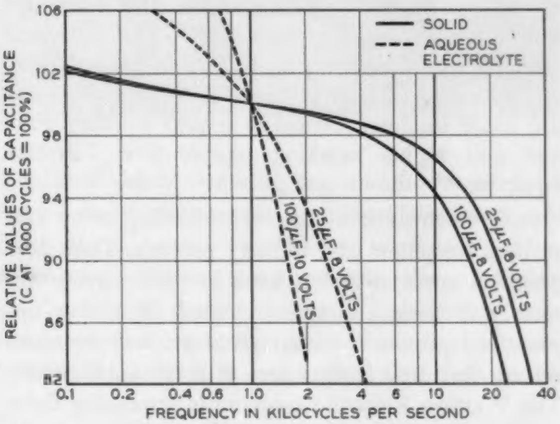


Fig. 4 — The tantalum solid capacitor retains much of its capacitance at high frequencies.

As shown in Figure 6, solid electrolytic capacitors have the highest Q's at elevated frequencies of any electrolytic capacitor. Figures 4 and 6 compare solid and aqueous type capacitors of identical capacitance and voltage ratings. It may be observed from the two bottom curves in Figure 6 that the Q value of the solid electrolytic capacitor falls off at a higher frequency than the Q value of the wet type.

Solid electrolytic capacitors have extremely good shelf life at both room and elevated temperatures, and they need no periodic voltage application to maintain their electrical characteristics as do the wet electrolytic capacitors.

Fig. 5 — M. J. Urban checks life-test values on capacitor environment studies.

Behavior of these capacitors suggests that in the electrolytic formation, tantalum ions pass through the thin natural oxide film, combining with the oxygen around the anode surface. This results in an electrolytically formed Ta_2O_5 film with a slight excess of Ta ions. This Ta_2O_5 film, with Ta on one side and MnO_2 on the other, shows high resistivity in one direction. The MnO_2 itself has low resistivity. The MnO_2 also serves as a solid electrolyte and has one chemical function. As an oxidizing agent, it gives up some oxygen to the imperfections in the Ta_2O_5 film, healing the imperfections and reducing the leakage current.

Another type of solid electrolytic capacitor employs coils of tantalum wire or foil which have been etched with hydrofluoric acid. (See Figure 2.) Units with capacitances of a fraction of a microfarad can be obtained by this method in a considerable variety of capacitance and voltage ratings. These wire

TABLE I — COMPARISON OF CAPACITANCES OF SOLID AND WET ELECTROLYTICS AT HIGH FREQUENCIES

	1,000 cps	*50,000 cps*
Solid Electrolytic	90 mf	53 mf
Wet Electrolytic "A"	100 mf	14 mf
Wet Electrolytic "B"	250 mf	32 mf

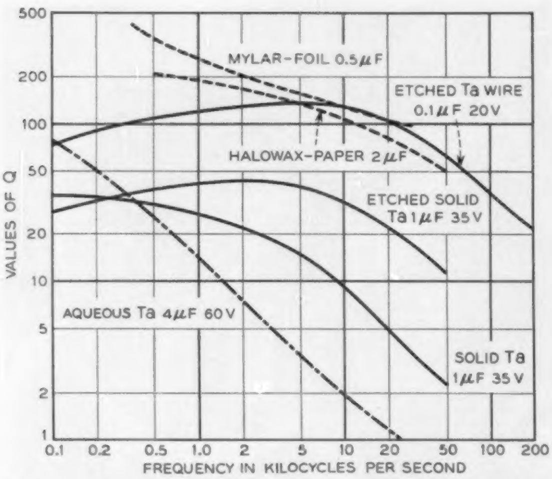


Fig. 6 — A feature of the solid tantalum capacitor is its ability to maintain Q values at high frequencies.

anodes may be formed up to 200 volts, and capacitors built on these anodes have low power-factor values as well as low dc leakage values. Preliminary tests show that they withstand an accelerated life test at elevated temperature without failure for 4,000 hours and are still in excellent condition after that time. Etching of the wire anodes removes surface layer contamination due to working of the wire. It also removes heat oxide spots which result from welding of the units. These factors probably account for the lowering of the leakage and power-factor values as compared with those of unetched samples. As seen in Figure 6, the etched wire capacitor compares favorably in Q value with paper and foil types.

A further development in this field has been the laboratory production of experimental non-polar units for circuits where a reversal of current may occur. These units are made by putting two polar units together in a series combination with an anode lead protruding in each direction. The power factor of the non-polar units has averaged 3.4 per cent at a frequency of 1,000 cycles.

Life tests have been under way on many of these capacitors for over two years. At room temperature and full rated voltage little change has been observed during this period. There is little deterioration in the smaller capacitors at 65°C and full rated voltage. Even larger units at 65°C and three-quarters of rated voltage perform well. Investigations are being directed toward increased working voltage and higher working temperature. Life-test equipment is shown in Figure 5.

Solid electrolytic capacitors are finding many uses in both telephone and military projects. Their first practical application has been in rural carrier systems and their use is anticipated in station apparatus equipment with transistors, and in numerous other Bell System and military applications. The Western Electric Company is producing them in pilot size lots and will provide modern commercial facilities for large-scale production in the Merrimack Valley plant.

THE AUTHOR

Mrs. F. S. Power, a native of Denver, Colorado, received her A.B. and M.A. degrees from the University of Denver in 1919 and 1920. After two years of teaching high school physics and chemistry, she entered the University of Illinois from which she received her Ph.D. degree in organic chemistry in 1925. She served as assistant professor, and then associate professor of chemistry at Lawrence College from 1925 to 1929. In 1929 she joined Scott and Bowne Laboratories as a research chemist, and was in charge of research there from 1932 to 1933. Mrs. Power joined the Laboratories in 1951 and since then has been closely associated with the development of tantalum solid electrolytic capacitors. She is a member of Sigma Xi, Iota Sigma Pi, and the American Chemical Society.

The AMA Assembler-Computer

T. C. REHM *Special Systems Development*

The assembler-computer recently designed for use in the Automatic Message Accounting system now does the work which formerly required two types of machines. Paper tapes perforated at various central offices contain billing information pertaining to many telephone calls with entries for a particular call scattered among those other calls. From tapes of this sort, the assembler-computer gathers entries and computes charges. This information is perforated on another tape for subsequent AMA stages.

A major factor in the postwar development of the Bell System plant has been the conversion of many manual offices to crossbar dial systems. Concurrent with this has been the introduction of AMA (Automatic Message Accounting) for the automatic recording of customer-dialed multi-unit charges and long distance calls.

In the AMA system, punched paper tapes containing the details of calls are sent from the central office to an automatic message accounting center. In this center, the tapes are processed through a series of Bell System machines to derive long distance and message unit charges for which customers are billed. Possible modifications of the AMA system have been studied intensively at the Laboratories and one result of these studies has been the development of the assembler-computer shown in Figure 1.

This apparatus does the work which required two separate types of machines – assemblers and computers – in earlier AMA centers. The new combined unit not only saves increasingly valuable floor space in the accounting centers, but also operates faster and more economically than the earlier machines.

To describe how the assembler-computer works, it is first necessary to review briefly the process by which an AMA tape is prepared in a central office. When a customer dials a charge call, a trunk or junctor which handles that call gains access to a recorder circuit.* This recorder circuit perforates the various entries on an AMA tape. The first or "initial entry" on the tape contains a variety of information including the calling customer's number, and in some cases the called customer's number. This entry is perforated on the tape when the connection is made. If the called customer answers, an entry is perforated which specifies the time of answer in minutes and tenths of minutes. Following this "answer entry," a "disconnect entry" is perforated on the tape to specify the time at which the conversation ended.

One recorder serves up to 100 trunks or junctors and its operation is such that it perforates an entry pertaining to a call as soon as the data is available. Therefore, elements of one particular call appearing on the tape are seldom adjacent; they may be separated by elements of calls placed

* RECORD, *December*, 1951, *page* 565.

there by other trunks having access to the same recorder, on which calls were also in progress. To identify these various entries so that they may be properly associated, each of the 100 trunks is assigned a two-digit number known as the call identity index. This index is made part of each call entry – initial, answer and disconnect – placed on the tape. "Hour" entries are also perforated on the tape at appropriate intervals. Each hour entry applies to all the succeeding call entries until a new hour entry appears.

In an assembler-computer in an accounting center, the perforated tape is fed into an AMA reader* as shown in Figure 2. As the entries are read, they are passed alternately to the A or B READING RELAY registers as shown in the figure. This enables the reader to run at a much higher speed than would otherwise be possible. From the A or B READING RELAY register an entry, which indicates the recorder number, day or hour, is stored in one "28" REGISTER, so called from the AMA code of these entries, shown in Figure 2. This information is subsequently used by the assembler-computer. Answer and disconnect entries are stored in the assembling registers as indicated in the diagram.

The assembling registers consist of 100 identical circuits each of which provides storage for the answer and disconnect time of one call. The registers are numbered from 00 to 99 and the circuit is so arranged that access to a register depends on the call identity index of the entry processed.

Tape entries are read in the reverse order from which they are perforated at the central office. Therefore, the first element of a completed call is the disconnect entry. This entry is stored in the assembling register whose number corresponds to the call identity index of the entry. Simultaneously the hour entry, which was stored in the "28" REGISTER, is obtained and is registered as part of the information. When the answer entry of the same call is encountered, it is stored in the same assembling register as determined by the call identity index. The hour information is also stored as described for the disconnect entry.

When the initial entry of the call is encountered as indicated by the call identity index, the associated disconnect and answer time information is removed from the assembling register storage. All elements are then assembled so that the charge time for the call can be computed by a relay computing circuit. The information from the initial entry and the computed charge are combined to form an output entry, which is perforated on the appropriate tape. Calls which were not answered are discarded during this process. The output of the assembler-computer consists of new tapes which are used, in turn, as the input for later stages of processing. Any calls which for some reason require other than routine handling are perforated on one of the "subsidiary" perforators of Figure 2.

Between entries of the call described above there may be entries of other calls. Any combina-

* RECORD, *June*, 1952, *page* 237.

Fig. 1 — The assembler-computer replaces assemblers and computers in older installations of automatic message accounting equipment.

tion of entries may be encountered, but considering the components of one call, the disconnect, answer and initial entry will always be in the same relative order and each will be handled as described.

Upon the arrival of the first initial entry on the tape, which can consist of 2, 4, or 5 lines depending on the type of call, connection to the side 1 "entry register" is established as shown in Figure 2. Successive lines of the entry are read alternately by the A and B READING RELAYS, but all are stored in the side 1 entry register. While the first line of the initial entry is being registered, the answer and disconnect times for the call are taken out of the storage registers and reregistered in the computer. The computer determines the elapsed time, and receives further information from the entry register which enables it to determine whether message unit charges are required. If they are, the proper formula circuit* is selected and the charge computed. These charges and additional information on how the call shall be handled, such as whether it is to be a completed charge call, an uncompleted call, or an entry to be placed on one of the subsidiary tapes, are determined and stored in the entry register. The message unit charge computation proceeds concurrently with the reading of subsequent or "supplementary lines" of the initial entry.

All information on each call is registered and checked before perforation of the output entry is begun. To achieve the desired over-all speed of 25 lines per second, the punch magnet circuit in the perforator is directly controlled by the reader. The output is perforated one line at a time under the control of successive reader cycles. Paths to the punch magnets determining the particular make-up of a line are prepared during the open interval of the perforator punch magnet circuit by one of many "pattern" relays which closes before the start of a reader cycle and opens afterward. During a particular open interval, the pattern relay for the line just perforated releases and the pattern relay for the next line operates.

While the output tape is being perforated, the input tape is again read, and the timing or initial entries (if they follow) are registered in the assembling registers or in the side 2 entry register, respectively. When the entry in side 1 is completely perforated, those registers are released. When the entry in side 2 has been completely registered, it too is perforated as described above. As this perforation takes place, the side 1 entry register may again be filled, and this process is repeated, alternating between side 1 and side 2 throughout the entire process. By this means, the input tape is read at an almost continuous rate. Delays do occur occasionally, however. There are, for example, cases where five lines must be perforated for every four lines read. In this situation, the reader remains on the same line for two successive cycles.

In the assembling registers, information is stored through the use of two types of dry-reed relays. Five "reeds" or switches, each actuated by a separate coil, form a register unit, and twelve switches controlled by a common coil form a connector unit. Access to the dry-reed registers is gained through dry-reed connectors which are arranged so that terminals project from both ends of the container. Connection to the common side is obtained by "banjo" wiring down the bay as illustrated by Figure 3. The other ends of the connectors are wired to the individual registers.

A timing entry is stored in five register relays;

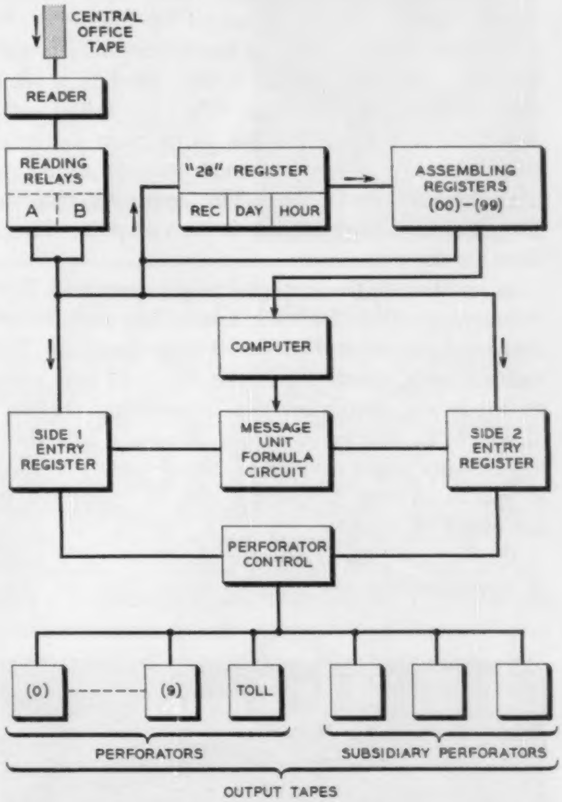


Fig. 2 — Block diagram of assembler-computer operation in automatic message accounting.

* RECORD, *July*, 1952, *page* 289.

one each for tens of hours, hour units, tens of minutes, minute units, the tenths of minutes. Each of these values is stored in 2-out-of-5 code, except the tens of hours which uses a 1-out-of-3 arrangement. With five such relays provided for each answer, and another five for disconnect, ten relays per assembling register are required. Since storage for 100 answers and disconnects is required, a total of 1,000 such relays are used. Further, each relay package has a capacity of five "bits" so a total of 5,000 bits is furnished in the machine for the assembling function. When a disconnect entry is encountered on the central office tape, each of the five timing digits is stored by closing paths to the dry-reed registers in the appropriate group. Similarly, the answer time is registered in a separate set of storage registers. When the initial entry of a call is encountered, the paths from the associated answer and disconnect storage relays to the computer are closed. The computer receives the information and uses it to compute charge time for the call.

In addition to the dry-reed relays described, four wire-spring relays for each assembling register are also used for control of the storage function. The entire circuit, consisting of the dry-reed and wire-spring relays, comprises the "assembling register" of which, as mentioned earlier, there are 100 working circuits. Four additional circuits are provided as spares so that processing can be continued in the event of trouble.

An electron tube connector check circuit is used in the assembler-computer to insure that the dry-

Fig. 3 — "Banjo" wiring interconnects dry-reed switches in assembling registers.

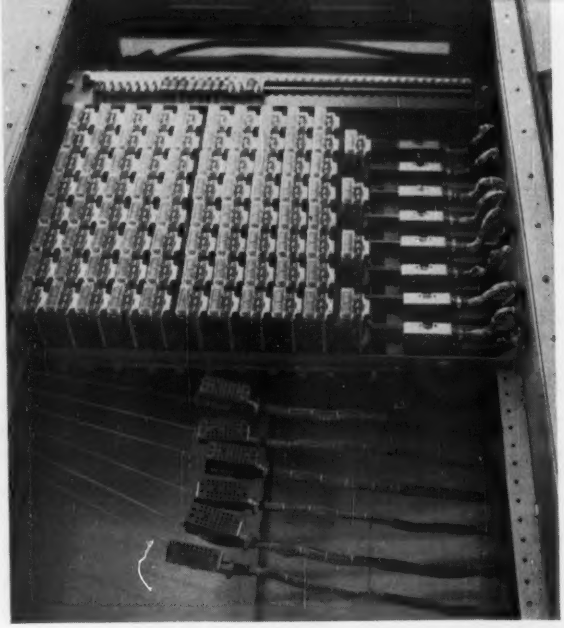


Fig. 4 — Plug-in "formula" circuits contribute to ease of maintenance of the new equipment.

reed connector has operated before either the timing or computer connector is permitted to operate. This circuit also insures that only one of the disconnect or answer connectors is operated when a timing entry is registered, but that both are operated when the register is to be connected to the computer. These precautions are taken for two purposes: to reduce the hazard of storing a timing entry in a register to which it was falsely connected and to improve dry-reed contact life and reliability by preventing these relays from closing or opening contact loads.

The charge for a message unit call is based on the charge time computed for that call and by the billing index. This charge is determined in the assembler-computer by a circuit similar to that used previously in the accounting center equipment. A significant change was made in the equipment arrangement, however, in that each "formula" circuit occupies two mounting plates arranged on a plug-in basis. Figure 4 shows four formulas installed and spare connectors for three more. These units make it considerably easier to change rates when necessary, and to maintain the system.

One bay of relay equipment includes the formula circuits described above. Four such bays are required for the assembling registers, with six more for entry storage, computing, perforating and control, making a total of eleven bays. One AMA reader in a reader cabinet, and up to 14 AMA perforators in seven perforator cabinets complete an installation. In addition to the dry-reed relays, more than 2,300 wire-spring relays are used.

Experience has shown that one assembler-computer replaces about three assemblers and three computers. In addition to shortening the time required for an accounting center to process a particular central office's tapes, the assembler-computer offers a number of other advantages including savings of AMA tape and reduced operating effort. The machine has thus proved to be a significant contribution to improved accounting center operation.

THE AUTHOR

T. C. Rehm, a native of Haledon, N. J., joined the Laboratories upon graduation from Cornell, 1937 with the degree of Electrical Engineer. He was initially associated with testing and development of step-by-step and manual switching systems, and during World War II he transferred to the Transmission Development Department, where his work was concerned mainly with pulse modulation and carrier systems. After the war, he spent a short time on a project studying relay contact life, and he later became a member of a group developing circuits for the AMA accounting center. About 1950 he engaged for a time in the development of circuits for CAMA in crossbar tandem offices, subsequently returning to accounting center development, where his work mainly concerned the assembler-computer. Mr. Rehm is now engaged in developing circuits for SAGE. He is an Associate Member of the A.I.E.E. and a member of Eta Kappa Nu.

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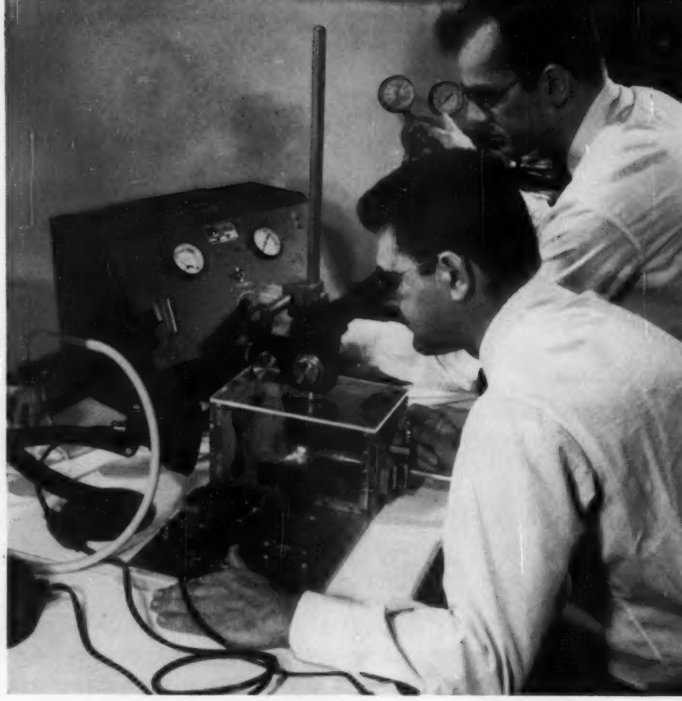
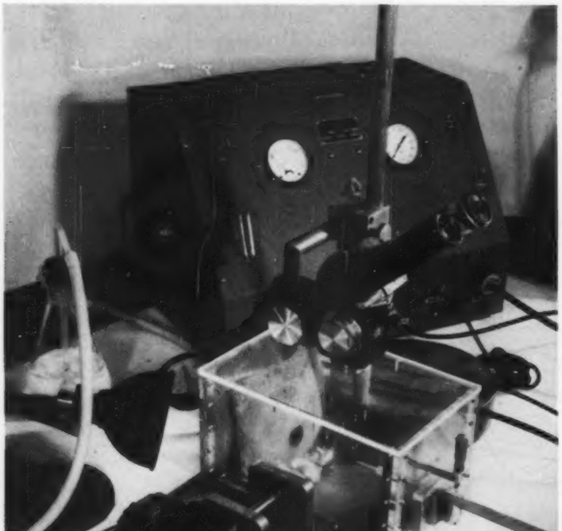
An Improved Way to Cut Cylindrical Crystals



F. Barbieri watches crystal shaping progress through a microscope while J. Durand adjusts control unit to regulate abrasive stream.

The study of the positions of atoms in crystals (crystal structure) by x-ray diffraction techniques is necessary for the fundamental understanding and accurate prediction of the physical and chemical properties of crystal materials. The cylindrical shape is one of the most desirable for such studies, because it simplifies making corrections for x-ray absorption. A method for cutting and shaping fragile crystals into nearly perfect cylinders was for some time a problem to the crystallographer.



Among the available methods of shaping cylinders, the most promising was originated by Dr. R. Pepinsky of Pennsylvania State University. He used as a cutting medium a device designed to project a stream of abrasive particles in a dry inert gas carrier. This commercial cutting equipment is sold by the S.S. White Dental Manufacturing Commany under the trade-mark "Airbrasive." An extension of this method devised recently in the Laboratories consists in shaping the crystal with the abrasive stream inside a partially evacuated hood of transparent plastic. The shaping equipment provides a stream of abrasive particles directed through a nozzle at the work, in this case the crystal, and by impingement produces a cutting action. The equipment as it appears in use is shown in the photograph at the top of the page. The apparatus is small and compact, and except for the cutting unit, is made from readily available laboratory equipment.

The basic principle of the apparatus is that of a lathe, with the abrasive stream as the cutting tool. The typical laboratory arrangement of the apparatus units is shown in Figure 1. The turning unit of the lathe is a shaft, mounted in bearings which allow it to reciprocate ¼ inch along its axis 11 times per minute while rotating at 115 rpm. The shaft and

Fig. 1 — Laboratory set-up for shaping fragile crystals showing important elements of apparatus.

the motors which control turning and reciprocating appear at the left of the transparent hood in Figure 1. The reciprocating action assures uniform cutting of the cylinder along its main axis, and is furnished by the action of an eccentric cam and a return spring. The end of the shaft which carries the goniometer head – a precision universal mounting device – with the crystal mounted in it, protrudes into the transparent hood from the left. The hood is made airtight and the pressure inside is reduced to about 600 mm of mercury so that air currents inside will not affect the evenness of the abrasive stream.

The nozzle which directs the abrasive stream is mounted on a slide at one end of the hood so that it can be placed very close to the crystal and raised or lowered by hand from the outside with a micrometer screw. This mounting arrangement is on the right, or front, face of the hood. The opposite end of the hood has an oiled screen to catch most of the abrasive; the rest is captured in the vacuum abrasive trap, left.

As a typical example, an extremely fragile crystal with pronounced cleavage, guanidinium aluminum sulphate hexahydrate* was cut to a cylinder of 0.3 mm diameter in less than 2½ hours. The crystal, which was first cut to an ⅛ inch cube, was heated to 80°C, and while still hot was mounted with wax on a brass pin. The pin was in turn mounted in a goniometer head with the crystal oriented with its cleavage plane perpendicular to the axis of rotation. The cutting was started with the stream of abrasive in a nitrogen carrier at 80 psi and a nozzle feed of 0.001 inch per minute. As the crystal diameter decreased, the feed and pressure were reduced. The cutting was continued until a diameter of 0.25 mm was obtained. At this point, small portions began to cleave off the end of the crystal, and cutting was stopped. A photograph of this crystal cylinder is shown in Figure 2. Where less fragile crystal materials are studied, this method will probably produce cylinders smaller than 0.25 mm in diameter.

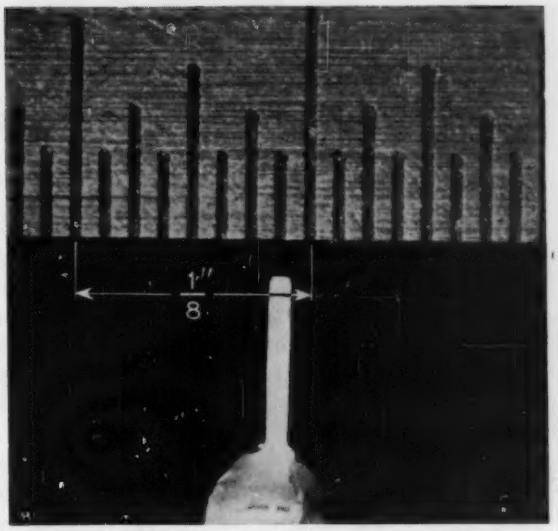


Fig. 2 — Enlarged photograph showing GASH crystal cylinder cut in the laboratory. The cylinder axis is perpendicular to the main cleavage plane.

* RECORD, *April*, 1956, *page* 121.

F. BARBIERI and J. DURAND
Research in Physical Sciences

N.Y.U.-Laboratories Graduate Program Expanded

A broadening of the curriculum to be offered, beginning this fall, at the New York University graduate-study center at Bell Laboratories has been announced by representatives of the Laboratories and of the University.

Courses of the Communications Development Training Program now may lead in two years to masters' degrees in mechanical engineering and engineering mechanics, as well as in electrical engineering as originally announced.

The program of courses offered at the center in the first year will be applicable toward credit in any of the three fields. During the second year, offerings of the center will include courses in mechanical engineering and engineering mechanics as well as in electrical engineering.

In cases where requirements for the master's degree cannot be completely satisfied by courses taken at the center, any requirements remaining may be met by courses taken at New York University under the Graduate Study Plan.

For those already holding masters' degrees, course credits earned at the center may be offered in partial fulfillment of the requirements that are necessary for the doctorate degree within the limits of applicable university regulations.

"Over-the-Horizon" Service Between Florida and Cuba

A new "over-the-horizon" microwave radio service began operation in September to supplement existing deep-sea cables now used for telephone communications between the United States and Cuba. This marks the first regular interconnection of Cuban and American TV stations and the first time such a system has been made available for commercial television.

The 185-mile link, between Florida City, Florida, and Guanabo, Cuba, is a joint undertaking of the Long Lines Department of the A.T.&T. Co. and the Radio Corporation of Cuba, a subsidiary of International Telephone and Telegraph Corporation.

The mechanism of over-the-horizon transmission is sometimes referred to as "scatter propagation." The scattering does not occur, however, in the same sense that a beam of light is scattered in all directions when passing through fog. Rather, the scattering is largely downward toward the earth, so that the result is somewhat similar to the reflection of short-wave signals from layers of the atmosphere.

Bell Laboratories work on "over-the-horizon" transmission* dates back many years. In 1950 a group under the direction of Kenneth Bullington conducted pioneering experiments at the Whippany, N. J., Laboratories location. With measurements of received signals at distances up to 285 miles from a transmitter, these experiments disproved the assumption that microwave transmission would be unreliable at distances beyond the optical horizon. Received signals were hundreds of decibels stronger than predicted from classical theory.

Later, in cooperation with Massachusetts Institute of Technology, the Laboratories operated an experimental broadband over-the-horizon circuit between the Holmdel, N. J., Laboratories location and the M.I.T. Round Hill Research Station near New Bedford, Mass., a distance of 188 miles. The over-the-horizon technique has also been used to provide military communications. (See page 435.)

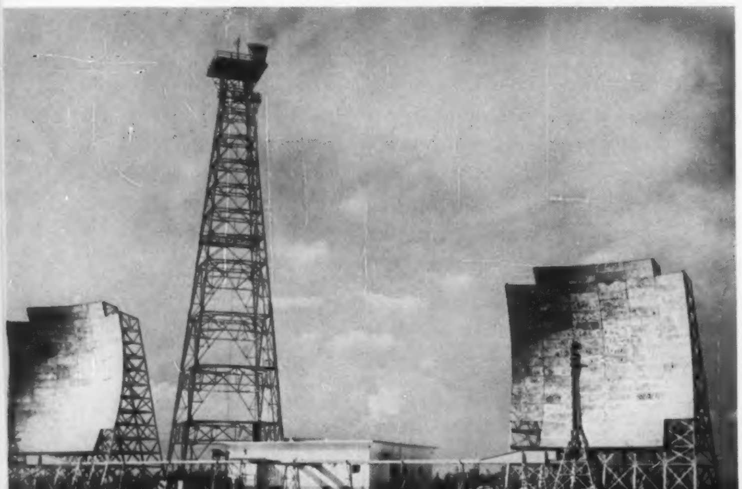
The transmitters of such systems emit large amounts of microwave energy in the direction of the receiving antenna, which is located at a point beyond the horizon. Radio beams are focused, much like the beam of a searchlight, from a 60-foot square transmitting antenna. With the curvature of the earth blocking a direct path to the receiver, the signals travel outward into the troposphere. There are apparently sufficient irregularities in this air mass to cause some of the energy to be reflected or refracted downward. Only a minute portion of the microwave energy transmitted is received at the distant point, but this small amount is enough in most cases to permit reliable communication.

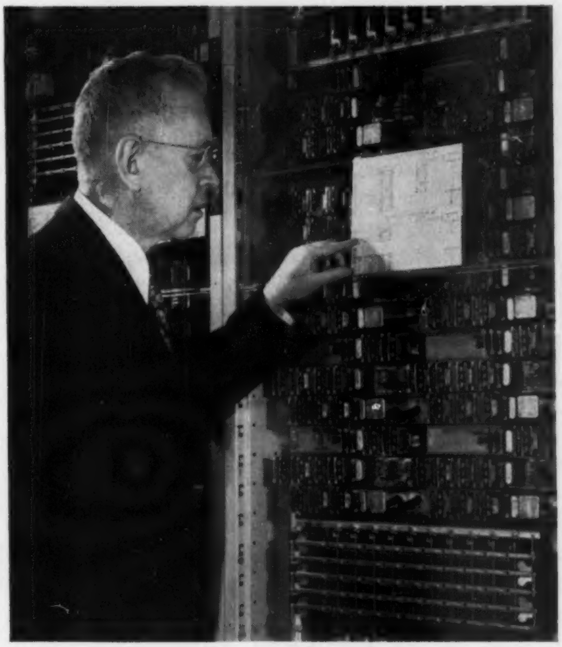
"Over-the-horizon" systems are different from microwave radio-relay systems now widely used in this country. Conventional microwave requires "line-of-sight" transmission, and the signals are amplified at intermediate stations spaced every 30 to 40 miles. "Line-of-sight" radio relay is used to interconnect with networks of the U. S. and Cuba.

Construction of antennas and installation of feedhorns and terminal building equipment at Florida City were started in March of this year. The site was selected to provide as short a path as possible to Cuba and at the same time to obtain a reasonable amount of protection from possible hurricane damage along the coast. Consideration was also given to avoiding any interference with existing or proposed UHF television in southern Florida.

The antennas, designed by Bell Laboratories in cooperation with the Blaw-Knox Corporation, resemble large outdoor movie-screens. They are heavy steel structures, covered with thin steel "skinplate" reflectors. Horns centered 50 feet off the ground in front of the reflecting antennas feed the transmitted radio signals toward the plates, where they are focused in a beam aimed in the direction of the distant receiving antennas.

* RECORD, *June*, 1952, *page* 245; *May*, 1955, *page* 197; *February*, 1956, *page* 197.





Intermarker Group Operation in No. 5 Crossbar

M. C. GODDARD
Switching Systems Development I

In the No. 5 crossbar system, a group of markers directs the central office switching equipment to establish the proper talking path through that office. Some telephone buildings, however, house more switching equipment than a group of markers is designed to handle. Where this situation exists, the equipment is subdivided with separate groups of markers serving each division. An arrangement called "intermarker group" operation is then used. This arrangement results in significant savings to the telephone companies as well as improved service.

In the No. 5 crossbar system, markers are assigned the task of establishing a path through the switching equipment for each originating and terminating call. It is a common control system in that one group of markers serves all the associated lines and trunks. Some telephone buildings, however, house equipment that serves more lines and trunks than one common group of markers is designed to handle. In this case, the equipment is subdivided into groups, each served by a separate marker group. Where two or more marker groups are used in one building, a call from a customer served by one marker group to a customer served by another marker group uses intermarker group operation of the customer-to-customer type.

A multi-marker-group building may use separate groups of outgoing trunks and incoming trunks for each marker group, where the amount of traffic requires sizable groups. The trunk groups with lighter traffic loads may be used in common by two or three marker groups. In this case, two other types of intermarker group operation are involved; one, customer-to-trunk for outgoing calls and the other, trunk-to-customer for incoming calls. These lighter traffic groups appear in one marker group and calls outgoing from and incoming to that marker group are handled without affecting the other marker group. Calls to and from the other marker groups, however, are switched through the first marker group.

For customer-to-customer type intermarker group operation, the markers in the calling and called groups operate substantially the same as they do for calls where the calling and called customers are both served by No. 5 crossbar equipment located in two separate buildings. Figure 1 shows a block diagram for this interbuilding operation.

When a calling customer has completed dialing a called customer's directory number into an originating register for an inter-building call, that

register requests a marker in the calling group. That marker selects an idle outgoing trunk circuit to the called marker group, and an idle outgoing sender accessible to that outgoing trunk. It then connects the trunk to the sender through the sender link. It also selects an idle path between the selected trunk and the calling line through a trunk link, junctor and line link; connects the trunk and line through this selected path, and dismisses the originating register.* The marker then resumes its idle condition, leaving the outgoing sender connected through the sender link, outgoing trunk circuit and trunk conductors to the incoming trunk circuit. A seizure signal from the sender causes the incoming trunk to be connected to an idle incoming register through the incoming register link. The trunk conductors are thus connected through to the incoming register. This register sends a start pulsing signal to the sender when the register is ready to receive the called number. The sender then transmits the called number, usually as multifrequency pulses, to the register. The sender then transfers the trunk conductors to a holding path in the outgoing trunk and the sender releases. At the same time the incoming register requests the services of a marker which establishes the connection to the called line.

Intermarker group operation of the customer-to-customer type is illustrated by the block diagram in Figure 2. The marker in the calling group functions the same as above, as does the marker in the called group. The trunk and sender selected, however, are of the intermarker group types rather than the outgoing type. Since there is no incoming trunk or incoming register, there is no use for an incoming register link for this traffic. The outgoing and incoming trunks have been combined into one circuit having less apparatus than in the two trunks, primarily because there is no need for relaying supervision or for signaling over a distance. Also the intermarker group sender has the called number information recorded on relays by the calling marker in a form usable by the called marker. Since the intermarker group sender does not send pulses, it does not have a strong claim to the title, "sender." As a matter of fact, it masquerades as an incoming register in the called marker group. The called marker obtains the called number from this so-called sender through an incoming register marker connector.

The number of the trunk link frame which contains a trunk with an incoming interoffice call is normally furnished to the called marker by the incoming register link. Since this equipment is omitted in an intermarker group arrangement, trunk location information must be supplied in some other way. This is done by signaling between the intermarker group trunk and the intermarker group sender through the sender link. The trunk location signal is then translated and transmitted to the called marker through the incoming register marker connector.

If an intermarker group trunk is arranged to handle calls that are billed by automatic message accounting, an additional function is required. After the calling marker releases, the intermarker group sender initiates a request for the calling marker

* Record, *November*, 1950, *page* 502.

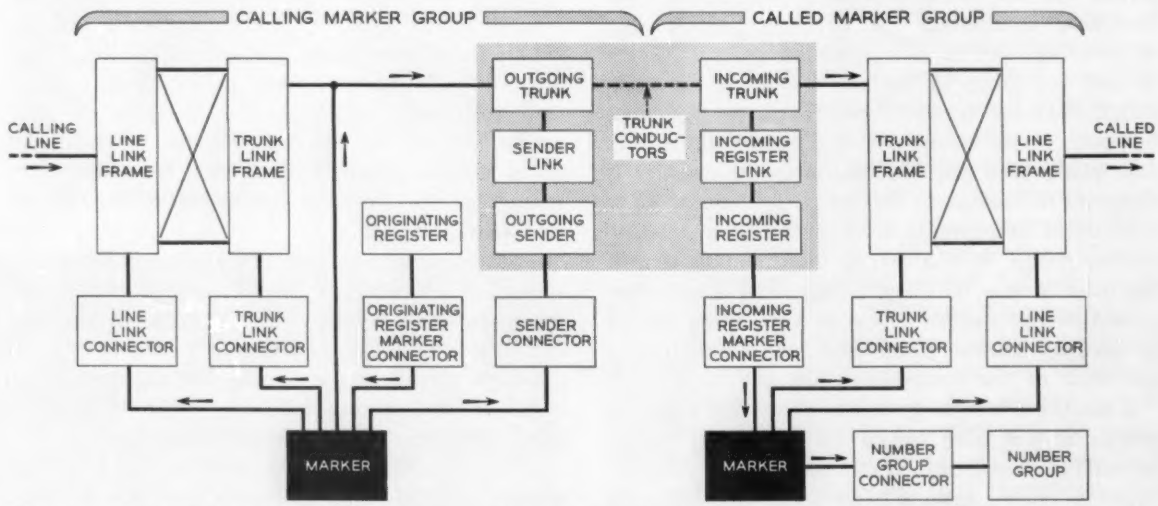


Fig. 1 — Typical inter-building operation between markers in the No. 5 crossbar system.

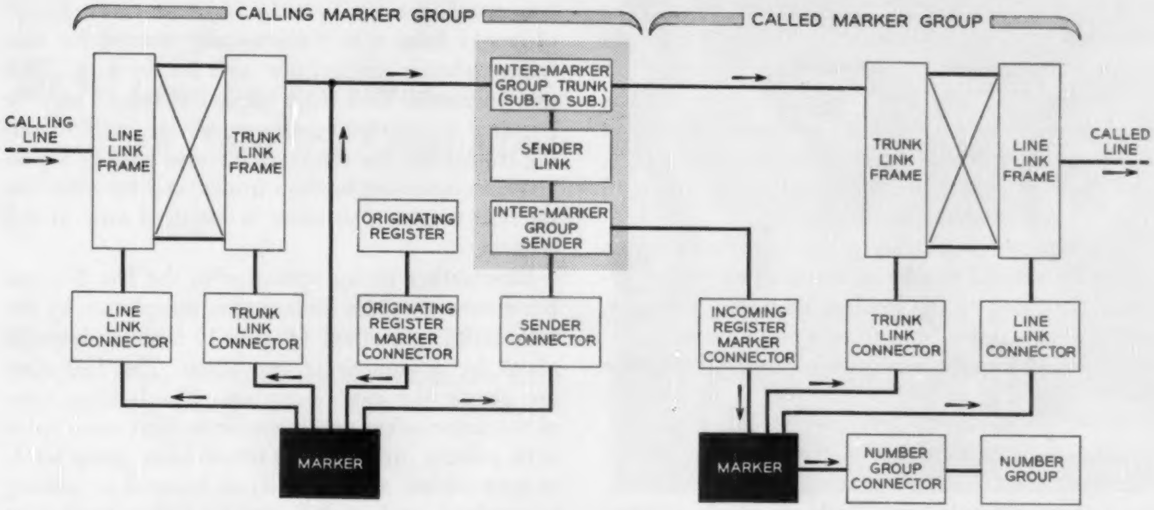


Fig. 2 — Intermarker group operation of No. 5 crossbar markers of the customer-to-customer type.

group AMA equipment to make the initial entry on an AMA tape. After this entry is completed, the sender acts like an incoming register to have the call completed in the called marker group.

For customer-to-trunk operation, one of the marker groups is made a tandem marker group. Light traffic trunk groups between the tandem marker group and outlying offices are made large enough to handle traffic from both the tandem and nontandem marker groups in the one building. A call, from a customer served by the tandem marker group, that is to be routed over one of these tandem trunks is completed like any other outgoing call that requires a sender. When a customer served by the nontandem marker group originates a call that is to be routed over such a trunk, however, it is completed by intermarker group operation using a customer-to-trunk type trunk. The calling end of the intermarker group trunk operates in the calling marker group as an outgoing trunk, but the called end operates in the called marker group as an incoming tandem trunk arranged to handle through calls only.

As in the case of the outgoing trunk groups, many incoming trunk routes are large enough to warrant having a separate group to each marker group but others are too small and should be combined. These combined groups are brought in as incoming trunks to the tandem marker group. Calls incoming over these trunks to customers served by the tandem marker group are completed just as they ordinarily would be on an incoming

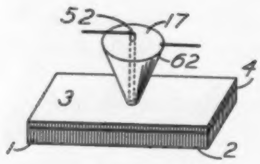
THE AUTHOR

M. C. Goddard, a native of Sidney, Maine, was in the U. S. Army from 1917 to 1919 and was graduated from Worcester Polytechnic Institute in 1921 with the B. S. degree in Electrical Engineering. He joined the Engineering Department of the Western Electric Company in June of that year, and has since been continuously with that organization and with the Laboratories. During his first nine years in the Bell System, Mr. Goddard was successively concerned with maintenance and descriptive circuit information, with laboratory testing of circuits, and with adaptation of standard circuitry to special field conditions. From 1930 to 1942 he designed circuits for the step-by-step system, and during World War II was a member of the teaching staff on the Laboratories School for War Training, where he specialized in airborne radar. Since World War II he has been concerned with the development of the No. 5 crossbar system. He is a member of A.I.E.E. and is also a New York Licensed Professional Engineer.

(nontandem) trunk. Calls to customers served by the nontandem marker group, however, are directed through the tandem marker group to an intermarker group trunk of the trunk-to-customer type. The tandem marker group end of this trunk is arranged as an outgoing trunk for tandem completing only, and the nontandem, marker group end is arranged as a normal incoming trunk.

In a typical intermarker group installation, there might be several groups of intermarker-group circuits. Referring to the tandem marker group as T, and the nontandem group as N, such an arrangement would require intermarker group senders for traffic from T to N, and another for traffic from N to T. If the T marker group serves flat rate and AMA message rate customers, and the N marker group, flat rate, AMA message rate and coin customers, the following trunks are usually required: customer-to-customer flat rate trunks from N to T and from T to N; customer-to-customer AMA trunks from N to T and from T to N, and customer-to-customer coin trunks from N to T. In addition, three groups of trunks from N to T are usually needed for customer-to-trunk service; one each for flat rate, AMA and coin calls. Two more groups of trunks may be required for trunk-to-customer service on terminating traffic; one for returning reverse battery supervision to incoming tandem trunks, and the other for intertoll trunks. The latter is required only at toll centers.

Intermarker group operation in the No. 5 crossbar system provides savings over completion by the inter-building method (Figure 1) that are brought about by a number of conditions. The following are among the most important: The holding time of the intermarker group sender is short since there is no pulsing involved; the intermarker group sender contains less apparatus, again because no pulsing is required; no incoming register link is needed in the called marker group, and the trunks require no "interoffice supervision" apparatus between marker groups in the central office.



Patents Issued to Members of Bell Telephone Laboratories During July

Andrews, E. G., Cesareo, O., and Murphy, P. B. – *Digital Computer* – 2,797,862.

Beck, A. C. – *Directive Dielectric Antennas* – 2,801,413.

Blecher, F. H. – *D-C Summing Amplifier Drift Correction* – 2,801,296.

Cesareo, O., see Andrews, E. G.

Clemency, W. F. – *Control of Regular and Distant Talking Subscribers Sets* – 2,801,287.

Edson, J. O. – *Multiplexing Various Modes in Composite Conductors* – 2,799,006.

Felch, E. P. – *Crystal Oscillator Apparatus* – 2,801,337.

Graham, R. E. – *Wide Band Amplifier Using Positive Feedback* – 2,798,905.

Hebenstreit, W. B., and Pierce, J. R. – *Amplification of Microwaves* – 2,801,362.

Hogan, C. L. – *Magnetically Controllable Transmission System* – 2,798,205.

Hollenberg, A. V. – *Traveling Wave Tube* – 2,801,359.

Koller, F. W., and Tomer, H. G. (The Thomas and Betts Co., Inc.) – *Shield Connectors* – 2,798,113.

Lovell, C. A. – *Multifrequency High Speed Calling Signal Generator* – 2,799,729.

Lovell, C. A., and Murphy, O. J. – *High Speed Polytonic Calling Signal Generator Employing Kick Coil* – 2,799,-730.

Lund, N. K. – *Signal Seeking Self Adjusting Radio Receiving System* – 2,798,944.

Meacham, L. A. – *Equalizing Circuit* – 2,801,288.

Mills, J. K. – *Current Supply Apparatus* – 2,798,167.

Murphy, O. J. – *Pulse System Producing Nulls in Electrical Networks* – 2,801,050.

Murphy, O. J., see Lovell, C. A.

Murphy, P. B., see Andrews, E. G.

Oliver, B. M., and Shannon, C. E. – *Communication System Employing Pulse Code Modulation* – 2,801,281.

Peek, R. L., Jr. – *Contact Springs* – 2,800,535.

Pierce, J. R. – *High Frequency Amplifier* – 2,801,361.

Pierce, J. R., see Hebenstreit, W. B.

Robertson, G. H., and Walsh, E. J. – *Traveling Wave Tube* – 2,801,360.

Robertson, G. H. – *Electron Discharge Devices* – 2,801,358.

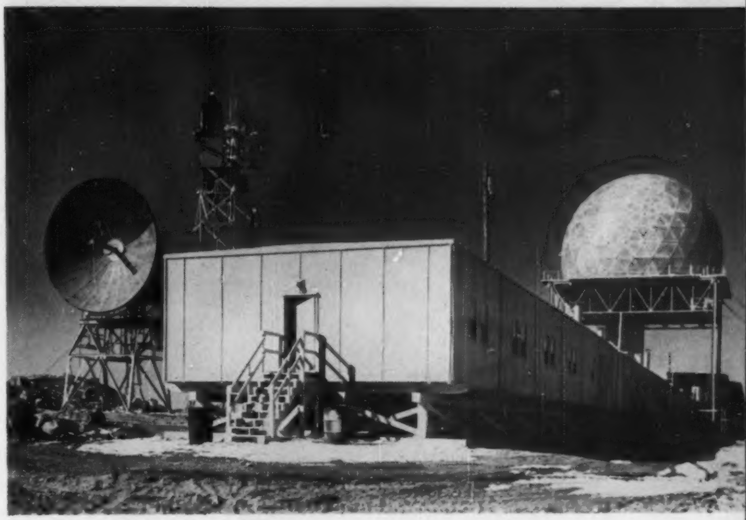
Robertson, G. H. – *Modulated Electron Discharge Device* – 2,798,203.

Ruble, G. B. – *Communication Circuit Employing Gas Tubes* – 2,801,284.

Shannon, C. E., see Oliver, B. M.

Walsh, E. J., see Robertson, G. H.

DEW Line Ceremonies Mark Network Completion



Outpost along far-north defense network: DEW Line antenna and "radome"—U.S.A.F. photo.

The Arctic Distant Early Warning (DEW) Line has been completed by the Western Electric Company, and acceptance by the United States Air Force was marked by ceremonies in Point Barrow, Alaska, on August 13. At the ceremonies, Vice President W. C. Tinus represented the approximately one hundred Laboratories people associated with the vast DEW Line project.

During the summer, Bell Laboratories and Western Electric completed pre-operational tests, and the 3,000-mile system was placed in operation on July 31. At that time, Western Electric Company turned over the completed DEW Line to Brig. Gen. Stanley T. Wrays, Electronic Defense Systems Division of the Air Materiel Command, who assigned responsibility to the International Telephone and Telegraph Corp. for the operation and maintenance of the line under the supervision of the Air Force. The DEW Line, which was begun late in 1954, was completed by Western Electric Company in 32 months and on schedule.

The completion of construction of the DEW Line culminates a project begun several years ago by the Department of Defense and the United States Air Force, when they enlisted a group of the nation's foremost scientists to study the problems of defense against polar attack. These men, including J. M. West and B. McMillan of the Laboratories, were known as the "Summer Study Group" of the Massachusetts Institute of Technology Lincoln Laboratories. The recommendations of this group formed the foundation for the work which was to follow.

For the DEW Line project, Bell Laboratories supplied technical guidance for the detection and communication equipment. Work proceeded on a "crash" basis to establish initial criteria for siting the detection stations and to determine propagation characteristics, using available electronic equipment where possible and improvising where necessary. After a test line was successfully evaluated, the Air Force again called upon Western Electric to act as prime contractor in establishing the final line. From this time, late in 1954, until the recent completion of the DEW Line, Bell Laboratories guidance was constantly in demand for design improvements, use of the new "forward scatter" radio technique for broadband, beyond-the-horizon communications (see page 430), development of a new radar and an automatic alarm system, and for technical and scientific know-how to solve the many complex and difficult problems of this unique communications network.

In commenting on the completion of the electronic installation, Mr. W. E. Burke, Vice President of Western's Defense Projects Division, stated, "These equipments are modern, reliable and technically advanced facilities which will provide effective detection and communication service meeting the military requirements presented to us. All of the Bell System people who were engaged in the project are naturally proud of meeting the required schedule and technical objectives."

Stretching from Western Alaska across the upper rim of the North American Continent, through Canada to Baffin Island and lying entirely above the Arctic Circle, the DEW Line will provide the United States and Canada with advance warning of the approach of airborne objects over the polar regions, allowing the greatest possible time margin.

"Cosmic Rays" Program on Television October 25

Frank Baxter explains how scientists proved that secondary particles carried an electric charge.

The third in the series of Bell System science programs will be telecast in color over the NBC network on Friday, October 25, at 9:00 p.m. EST. "The Strange Case of the Cosmic Rays" tells the story of the chain of investigations that led to the identification of one of Nature's most baffling phenomena – cosmic rays.

In the course of the program, a film sequence on Bell Laboratories will be presented as a sponsor's message. Showing a series of views covering many areas of research and development, the message will give viewers a brief look into the importance and significance of Laboratories work.

Included in the sequence are scenes from the areas of semiconductor research, microwave transmission development, electronic switching systems development, chemistry, mathematics, metallurgy and mechanical engineering. The theme of the sequence is contained in part of the announcer's introduction: ". . . here at Bell Telephone Laboratories, center of communications research and development, young men like these are asking the questions whose answers will help to bring you even better telephone service."

As in the two previous Bell System science programs – "Our Mr. Sun" and "Hemo the Magnificent" – Dr. Research and the Fiction Writer create the story in their science laboratory. A "detective-story" theme is used to explain the history of cosmic rays. This story is told to magic-screen characters Edgar Allen Poe, Charles Dickens, and Feodor Dostoevski – a trio of judges who are to choose the best mystery story of this first half-century. The authors are played by puppet creations of Bil and Cora Baird. Scientific material is presented during the course of the program through use of animation, documentary film, and still pictures of cosmic ray "tracks." Several of the latter are being presented on television for the first time.

The cosmic-ray story begins with an explanation of how the "culprit" was first discovered as an unknown form of radiation. Scientists then pick up the trail to locate the origin of this radiation. They determine that it comes from the cosmos, or outer space; hence the term "cosmic rays."

Identification of the "culprit" is pursued by the science detectives. They determine that the radiation consists of charged particles which bombard the earth with equal intensity all around the earth at all hours of the day and night. They further find that cosmic rays consist of two parts. Tremendously fast primary particles from outer space split atoms of air to result in secondary particles, which reach the earth's lower atmosphere.

Through study of the paths and other characteristics, secondary particles are proved to consist of electrons, protons, and neutrons. But in pursuing the nature of the primary particles, the scientists are overwhelmed with discoveries of many new particles of matter. Although recent research indicates that the primary cosmic rays consist of protons – certain atoms stripped of their electrons – scientists are still trying to discover the answers to important questions about these rays and what they mean to us. It is pointed out that so much is yet to be learned about this subject that the story cannot be considered finished.

More than a score of scientists are shown at work on cosmic ray research in this film. The value of their pure research on this subject is thoroughly

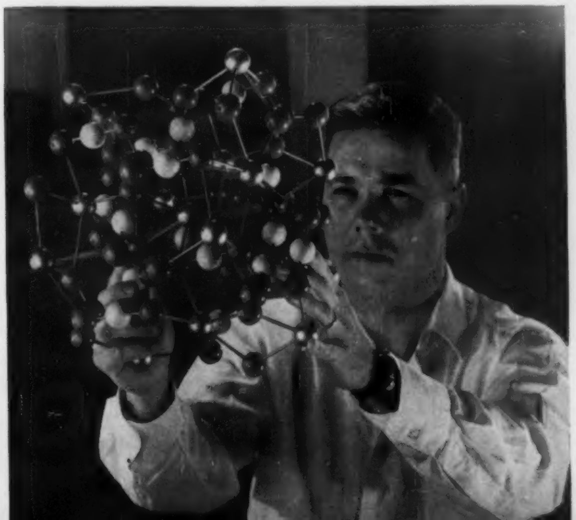
stressed. Although these men do not know just what cosmic rays mean to us or how we can use them to benefit humanity, they do know that these rays are one of nature's phenomena which presents a challenge to man's inquisitive mind.

A Scientific Advisory Board, composed of nine distinguished representatives from major fields of science, supervised preparation of the program material. Principal advisor in the production of "The Strange Case of the Cosmic Rays" was Dr. Carl D. Anderson, Nobel Prize winner and professor of physics at the California Institute of Technology. He was assisted by Dr. Bruno Rossi of Massachusetts Institute of Technology and Dr. Marcel Schein of the University of Chicago.

The Bell System Science Series is designed to have both educational and entertainment value in informing the television audience of work in the basic sciences and in promoting a greater interest and understanding of the phenomena which affect our daily lives. Another aim is to present to younger viewers the challenges and rewards of a scientific career. To this end, 16mm copies of the films in the series are distributed to lending libraries of all the Operating Companies following the nationwide telecasts. These are made available to local school systems requesting them.

The fourth program in the science series, entitled "The Unchained Goddess," is a scientific explanation of what makes weather, and is to be telecast on Wednesday, February 12, 1958 at 9:00 P.M. EST over the NBC network. "Our Mr. Sun" and "Hemo the Magnificent," initially presented on CBS, will also be telecast over NBC on December 15, 1957 and March 16, 1958, respectively. Expected to be ready for presentation in 1958 and 1959 are four new one-hour color films to be produced for the Bell System by Warner Brothers.

In scene describing research and development at the Laboratories, W. L. Brown studies atomic model.



Dr. Kelly Member-at-Large of the Defense Science Board

Dr. M. J. Kelly has accepted an invitation to serve as Member-at-Large of the Defense Science Board. The Board was established in line with recommendations of the Hoover Commission Subcommittee on Research Activities in the Department of Defense and Defense Related Agencies. Dr. Kelly was chairman of the subcommittee.

Donald Ross to Receive Civil Engineers Award

The American Society of Civil Engineers has announced that the Karl Emil Hilgard Prize will be awarded to Donald Ross of the Laboratories Underwater Apparatus Development Department. Mr. Ross will receive the award on October 16 at the Society's annual meeting in New York City. The honor is in recognition of a paper by Mr. Ross, "A Physical Approach to Turbulent Boundary Layer Problems," published in the 1956 *Transactions* of the American Society of Civil Engineers.

O. L. Anderson Named Chairman, Ceramic Society Glass Division

O. L. Anderson of the Mechanics Research Group in the Mathematical Research Department has been named chairman of the Glass Division of the American Ceramic Society. Mr. Anderson, one of whose chief concerns has been with the mechanical properties of glass, will serve as Chairman of the Division for one year.

Metals Society Award Honors Former Laboratories Microscopist

The American Society for Metals has announced the establishment of a Francis F. Lucas Award for Excellence in Metallography, named in honor of the former Bell Laboratories research microscopist. The award was endowed by Adolph E. Buehler, President of Buehler, Ltd., makers of metallographic equipment.

Francis F. Lucas, during his career at Bell Laboratories, did pioneering work on the preparation of samples for high-grade metallography, and was largely responsible for establishing standards in the field. He was a prolific author of many scientific papers for Bell System and other publications, and several of these papers are still basic to metallographic research. Mr. Lucas retired from the Laboratories in 1949.

J. P. Molnar

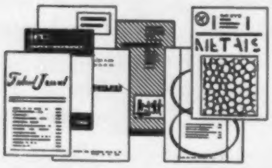
R. R. Hough

J. P. Molnar and R. R. Hough in New Posts

J. P. Molnar, Director of Military Development, has been elected a Vice President of the Laboratories. On September 1 he assumed the responsibilities held by R. R. Hough, who headed one of the two vice presidential areas devoted to military programs. Mr. Hough resigned from the Laboratories to accept a position as Assistant Chief Engineer of the A.T.&T. Co., also effective September 1.

Mr. Molnar was graduated from Oberlin College in 1937 with the A.B. degree, and received the Ph.D. degree from Massachusetts Institute of Technology in 1940. Prior to joining the Laboratories in 1945, he was employed with the National Defense Research Committee and with the Gulf Research and Development Company. Since joining the Laboratories, Mr. Molnar has been concerned with research in physical electronics and later with the development of microwave tubes. In 1955, he was appointed Director of Electron Tube Development and later in the year, became Director of Military Systems Development. In February, 1957, he was appointed Director of Military Development.

Mr. Hough was graduated from Princeton University in 1939 with a B.S.E. degree, returned to the Princeton Engineering School as an instructor and graduate student, and received an E.E. degree in 1940. He immediately joined Bell Laboratories and in 1941 became one of a group pioneering in the development of radar. He participated in the design and installation of the first U. S. naval gunfire control radar and made important contributions to the development of an army aircraft gunlaying radar. He received a War Department Certificate of Appreciation in 1946. In January, 1951 he was appointed Military Development Engineer, and in 1953, Director of Military Systems Development. He was named Director of Military Electronics Development in June, 1955, and in February of this year, he was elected a Vice President of the Laboratories. In 1947, he was the recipient of the Eta Kappa Nu Award as the "outstanding young electrical engineer."



Papers by Members of the Laboratories

Following is a list of the authors, titles and places of publication of recent papers published by members of the Laboratories:

Anderson, O. L., Christensen, H., and Andreatch, P., Jr., *A Technique for Connecting Electrical Leads to Semiconductors*, J. Appl. Phys., Letter to the Editor, **28**, p. 923, August, 1957.

Andreatch, P., Jr., see Anderson, O. L.

Breidt, P., Jr., see Greiner, E. S.

Chynoweth, A. G., and McKay, K. G., *Internal Field Emission in Silicon p-n Junctions*, Phys. Rev., **106**, pp. 418-426, May 1, 1957.

Christensen, H., see Anderson, O. L.

Dacey, G. C., and Thurmond, C. D., *P-n Junctions in Silicon and Germanium: Principles, Metallurgy and Applications*, Metallurgical Reviews, **2**, pp. 157-193, July, 1957.

Ellis, W. C., see Greiner, E. S.

Gianola, U. F., *Damage in Silicon Produced by Low Energy Ion Bombardment*, J. Appl. Phys., **28**, p. 868, August, 1957.

Glass, M. S., *Straight Field Permanent Magnets of Minimum Weight for TWT – Design and Graphic Aids in Design*, Proc. I.R.E., **45**, pp. 1100-1105, August, 1957.

Greiner, E. S., Breidt, P., Jr., Hobstetter, J. N., and Ellis, W. C., *Effects of Compression and Annealing on the Structure and Electrical Properties of Germanium,* J. Metals, **9**, pp. 813-818, July, 1957.

Hamming, R. W., see Hopkins, I. L.

Harker, K. J., *Nonlaminar Flow of Cylindrical Electron Beams,* J. Appl. Phys., **28**, pp. 645-650, June, 1957.

Herman, H. C., *Jumbo Case Considerations,* J. Patent Office Society, **39**, pp. 515-523, July, 1957.

Hobstetter, J. N., see Greiner, E. S.

Hopkins, I. L., and Hamming, R. W., *On Creep and Relaxation,* J. Appl. Phys., **28**, pp. 906-909, August, 1957.

Huang, K., Bohn, D., and Pines, D., *Role of Subsidiary Conditions in the Collective Description of Electron Interactions,* Phys. Rev., **107**, pp. 71-80, July 1, 1957.

Ingram, S. B., *Graduate Study in Industry — The Communications Development Training Program of the Bell Telephone Laboratories,* Engg. J., **40**, pp. 993-996, July, 1957.

Jaccarino, V., Shulman, R. G., and Stout, R. W., *Nuclear Magnetic Resonance in Paramagnetic Iron Group Fluorides,* Phys. Rev., Letter to the Editor, **106**, pp. 602-603, May 1, 1957.

Lander, J. J., See Morrison, J.

Legg, V. E., *Survey of Square Loop Magnetic Materials,* Proc. Conference on Magnetic Amplifiers, A.I.E.E., Special Publication, **T98**, pp. 69-77, Sept. 4, 1957.

Marcatili, E. A., *Heat Loss in Grooved Metallic Surface,* Proc. I.R.E., **45**, pp. 1134-1139, August, 1957.

McKay, K. G., see Chynoweth, A. G.

Meitzler, A. H., *A Procedure for Determining the Equivalent Circuit Elements Representing Ceramic Transducers Used in Delay Lines,* Proc. 1957 Electronic Components Symposium, pp. 210-219, May, 1957.

Miller, R. C., and Smits, F. M., *Diffusion of Antimony Out of Germanium and Some Properties of the Antimony-Germanium System,* Phys. Rev., **107**, pp. 65-70, July 1, 1957.

Montgomery, H. C., *Field Effect in Germanium at High Frequencies,* Phys. Rev., **106**, pp. 441-445, May 1, 1957.

Morrison, J., and Lander, J. J., *The Solution of Hydrogen in Nickel Under Hydrogen Ion Bombardment,* Conference Notes, M.I.T. Physical Electronics Conference, pp. 102-108, June, 1957.

Ruggles, D. M., *A Miniaturized Quartz Crystal Unit for the Frequency Range 2 Kc to 16 Kc,* Proc. 1957 Electronic Components Symposium, pp. 59-61, 1957.

Shulman, R. G., see Jaccarino, V.

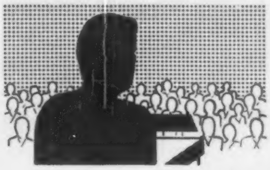
Smits, F. M., see Miller, R. C.

Stone, H. A., Jr., *Component Development for Microminiaturization,* I.R.E. 1957 Convention Record, Part **6**, pp. 13-20, 1957.

Thurmond, C. D., see Dacey, G. C.

Weinreich, G., *Ultrasonic Attenuation by Free Carriers in Germanium,* Phys. Rev., Letter to the Editor, **107**, pp. 317-318, July 1, 1957.

Weiss, M. T., *A Solid State Microwave Amplifier and Oscillator Using Ferrites,* Phys. Rev., Letter to the Editor, **107**, pg. 317, July 1, 1957.



Talks by Members of the Laboratories

Following is a list of talks given before professional and educational groups by Laboratories people during August.

Wescon, San Francisco, California

Abraham, R. P., *A Wide Band Transistor Feedback Amplifier.*

Bashkow, T. R., and Desoer, C. A., *Digital Computers and Network Theory.*

Bell, D. T., *Digital Computers as Tools in Designing Transmission Networks.*

Cagle, W. B., and Chen, W. H., *A New Method of Designing Low Level, High Speed Semiconductor Logic Circuits.*

Chen, W. H., see Cagle, W. B.

Chisholm, D. A., see Drexler, J.

Desoer, C. A., see Bashkow, T. R.

D'heedene, A. R., *Crystal Filters Developed in the Bell Telephone System.*

Drexler, J., and Chisholm, D. A., *Two Reflex Klystrons for Radio Relay Applications.*

Fleckenstein, W. O., see Michel, W. S.

Harding, P. A., *Synthesis of Minimum Delay Time Amplifiers.*

Hewitt, W. H., Jr., and von Aulock, W. H., *A Reciprocal Ferrite Phase Shifter for X-Band.*

Hughes, H. E., see Zuk, P.

Iwerson, J. E., Nelson, J. T., and Keywell, F., *A 5-Watt, 10-Megacycle Transistor.*

Karlin, J. E., see Pierce, J. R.

Keywell, F., see Iwerson, J. E.

Kretzmer, E. R., see Michel, W. S.

Talks by Members of the Laboratories, Continued

Lundry, W. R., *Negative Impedance Circuits – Some Basic Relations and Limitations.*

Ma, L. N., *Series Transistor Voltage Regulator Design Procedure.*

Malthaner, W. A., *Experimental Data Transmission System – Speed Translator Using Magnetic Tape.*

Mattingly, R. L., McCabe, B., and Traube, M. J., *The Split Reflector Technique for Broad-Band Impedance Matching of Center-Fed Antennas without Pattern Deterioration.*

McCabe, B., see Mattingly, R. L.

Michel, W. S., Fleckenstein, W. O., and Kretzmer, E. R., *A Coded Facsimile System.*

Nelson, J. T., see Iwerson, J. E.

Pierce, J. R., and Karlin, J. E., *Reading Rates and the Information Rate of a Human Channel.*

Poole, K. M., and Tien, P. K., *A Ferromagnetic Resonance Modulator.*

Robillard, T. R., see Westberg, R. W.

Seidel, H., *Viewpoints on Resonance in Ideal Ferrite Slab Loaded Rectangular Waveguides.*

Tien, P. K., and Poole, K. M.

Traube, M. J., and Mattingly, R. L.

Underwood, M. D., *The Large Signal Behavior of Alloy Junction Transistors with Inductive Loading in the Common Emitter Configuration.*

von Aulock, W. H., see Hewitt, W. H., Jr.

Westberg, R. W., and Robillard, T. R., *Complementary High Speed Power Transistors for Computer and Transmission Applications.*

Wiley, J. H., see Zuk, P.

Zuk, P., Wiley, J. H., and Hughes, H. E., *Diffused Silicon Diodes – Design, Characteristics and Aging Data.*

5th International Conference on Low Temperature Physics and Chemistry, Madison, Wisconsin

Bommel, H., *Ultrasonics as a Tool for the Study of Superconductivity.*

Bozorth, R. M., and Walsh, D. E., *Susceptibilities of Crystal of Europium Sulfate Octahydrate.*

Devlin, G. E., see Schawlow, A. L.

Dransfeld, K., and Wilks, J., *Heat Transfer Between Solids and He II.*

Geballe, T. H., and Hull, G. W., *Isotopic Thermal Resistance in Germanium.*

Hull, G. W., see Geballe, T. H.

Kunzler, J. E., and Wernick, J. H., *Low Temperature Resistance Measurements as a Means of Studying Impurity Distribution in Zone Refined Bars.*

Schawlow, A. L., and Devlin, G. E., *Structure of the Intermediate State in Superconductors.*

Walsh, D. E., see Bozorth, R. M.

Wernick, J. H., see Kunzler, J. E.

Wilks, J., see Dransfeld, K.

American Psychological Association, New York City

Bricker, P. D., *A Study of Human Talking and Writing Behavior in Relation to a Class of Possible Communications Systems.*

Deutsch, M., *Trust and Suspicion.*

Jenkins, H. M., *Auditory Generalization in the Pigeon.*

Karlin, J. E., *Past and Future Contributions of Engineering Psychology to Commercial (Nonmilitary) Industry.*

Karlin, J. E., see Pierce, J. R.

Pierce, J. R., and Karlin, J. E., *Reading Rates and the Information Rates of a Human Channel.*

Gordon Research Conferences, New Hampshire

Anderson, O. L., *The Debye Temperature of Vitreous Silica.*

Geller, S., *Rare-Earth Perovskites and Garnets: Preparative, Structural and Magnetic Studies.*

Lockwood, W. H., see Peters, Henry.

Mason, W. P., *Mechanical Relaxations in Fused Silica and Natural and Synthetic Quartz.*

McAfee, K. B., *Stress Enhanced Diffusion of Gases through Glass.*

Peters, Henry, and Lockwood, W. H., *Bonding Polyethylene to Rubbers and Metals.*

Spencer, A. T., *Adhesion to Oxide Films on Copper.*

Other Talks

Aschner, J. F., *Semiconductor Physics; Transistor Physics,* Universidad de las Andes, Bogota, Colombia.

Bemski, G., *Recent Developments in Transistors,* Centro Tecnico de Aeronautica, Sao Jose dos Campos, Brazil.

Draper, R. D., *Counseling, Interviewing and Performance Evaluation,* Rutgers University, New Brunswick, New Jersey.

Kohman, G. T., *Industry's Obligation in the Training of Gifted Students,* Topeka Rotary Club, Topeka, Kansas.

Kohman, G. T., *Preparing the Gifted Student for Industrial Research; Chemical Research at Bell Telephone Laboratories,* Topeka High School, Topeka, Kansas.

Mealy, G. H., *Sequential Circuit Synthesis,* Engineering Summer Conference Program, University of Michigan.

Reiss, H., *Interaction Among Impurities in Semiconductors,* Motorola Corporation, Phoenix, Ariz.; Ohio State University, Columbus, Ohio; Battelle Memorial Institute, Columbus, Ohio; and Pennsylvania State University.

Reiss, H., *Precipitation in Solids,* Ohio State University, Columbus, Ohio.

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